# TABLE OF CONTENTS

TABLE OF CONTENTS ........................................................................ iv

Table of Figures ................................................................................ vii

1. Disclaimers And Notices ............................................................... 1
   1.1 Specific Warnings ............................................................... 1
   1.2 General Warnings .............................................................. 1
   1.3 Operator Training ............................................................... 2
   1.4 Testing Limitations ............................................................ 2
   1.5 Critical Operating Factors ............................................... 2
   1.6 Disclaimer of Liability ....................................................... 4
   1.7 Electromagnetic Compatibility ......................................... 5

2. How to Use this Manual ............................................................... 6

3. Features of the DFX-544 ............................................................ 7
   3.1 Instrument Characteristics ............................................. 7

4. Fundamentals of Ultrasonic Testing ........................................... 9
   4.1 Discontinuity Considerations ......................................... 10
   4.2 Ultrasonic Transducer/probes & Sound Fields ........... 10
   4.3 Straight Beam Testing .................................................... 14
   4.4 Dual Element Testing .................................................... 14
   4.5 Angle Beam Testing ...................................................... 16
   4.6 Immersion Testing ......................................................... 18

5. Quick Start .................................................................................. 20
   5.1 Front Panel Controls ....................................................... 20
   5.2 Panel Calibration Memory ................................................. 24
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.3</td>
<td>Flaw Detection</td>
<td>26</td>
</tr>
<tr>
<td>5.4</td>
<td>Thickness Gauging</td>
<td>27</td>
</tr>
<tr>
<td>6.</td>
<td>Detailed Operation Instruction</td>
<td>29</td>
</tr>
<tr>
<td>6.1</td>
<td>Basic Menu Functions</td>
<td>29</td>
</tr>
<tr>
<td>6.1.1</td>
<td>Main Menu</td>
<td>30</td>
</tr>
<tr>
<td>6.1.2</td>
<td>Function Menu</td>
<td>39</td>
</tr>
<tr>
<td>6.1.3</td>
<td>Memory Menu</td>
<td>47</td>
</tr>
<tr>
<td>6.2</td>
<td>Menu Tree</td>
<td>56</td>
</tr>
<tr>
<td>6.3</td>
<td>Storage &amp; Recall of Calibration Setups</td>
<td>58</td>
</tr>
<tr>
<td>6.4</td>
<td>Flaw Testing</td>
<td>62</td>
</tr>
<tr>
<td>6.4.1</td>
<td>Basic Flaw Testing</td>
<td>62</td>
</tr>
<tr>
<td>6.4.2</td>
<td>DAC Operation</td>
<td>66</td>
</tr>
<tr>
<td>6.4.3</td>
<td>TCG Operation</td>
<td>69</td>
</tr>
<tr>
<td>6.4.4</td>
<td>Weld Inspection Using Trigonometry Mode</td>
<td>72</td>
</tr>
<tr>
<td>6.4.5</td>
<td>Weld Inspection Using the AWS Menu</td>
<td>75</td>
</tr>
<tr>
<td>6.4.6</td>
<td>A-LOG, A-Scan Storage</td>
<td>77</td>
</tr>
<tr>
<td>6.4.7</td>
<td>REF, Reference Waveform Comparisons</td>
<td>79</td>
</tr>
<tr>
<td>6.4.8</td>
<td>Contour &amp; Peak Echo Dynamics</td>
<td>80</td>
</tr>
<tr>
<td>6.5</td>
<td>Thickness Gauging</td>
<td>82</td>
</tr>
<tr>
<td>6.5.1</td>
<td>Basic Thickness Gauging</td>
<td>82</td>
</tr>
<tr>
<td>6.5.2</td>
<td>A-Cal</td>
<td>86</td>
</tr>
<tr>
<td>6.5.3</td>
<td>TCG for Reliable Gauging</td>
<td>88</td>
</tr>
<tr>
<td>6.5.4</td>
<td>T-LOG Thickness Storage (Numeric)</td>
<td>89</td>
</tr>
<tr>
<td>6.5.5</td>
<td>T-LOG Thickness Storage (Sequential &amp; Download)</td>
<td>90</td>
</tr>
<tr>
<td>6.5.6</td>
<td>T-FN Thickness Log Editing and Printing</td>
<td>92</td>
</tr>
<tr>
<td>7.</td>
<td>Power Supply</td>
<td>95</td>
</tr>
<tr>
<td>7.1</td>
<td>Lithium-Ion Battery Pack</td>
<td>95</td>
</tr>
</tbody>
</table>
### Table of Figures

- Figure 1 – Basic Ultrasonic Testing .......................................................... 9
- Figure 2 – Ultrasonic Energy Field Distribution ........................................ 12
- Figure 3 – Ultrasonic Beam Spread and Half-Angle .................................. 13
- Figure 4 – Typical Dual Element Transducer/probe ................................ 14
- Figure 5 – Thickness Gauging on Pipe ..................................................... 15
- Figure 6 – Couplant use on Pitted Surfaces ............................................ 15
- Figure 7 – Typical Angle Beam Transducer/probe .................................. 16
- Figure 8 – Typical Weld Inspection ........................................................ 17
- Figure 9 – Immersion Testing Method .................................................... 18
- Figure 10 – Focusing in Immersion Testing ............................................ 19
- Figure 11 – Front Panel of the DFX-544 .................................................. 20
- Figure 12 – Proper TX Width Setting ..................................................... 64
- Figure 13 – Improper TX Width Setting .................................................. 64
- Figure 14 – Cursor Selection of Echoes for DAC .................................... 67
- Figure 15 – DAC Curve and -6dB/-14dB Curves ..................................... 69
- Figure 16 – Equalization of Echoes Using TCG ..................................... 71
- Figure 17 – Trigonometry Mode Measurements ...................................... 72
- Figure 18 – Trigonometry Mode Measurements ...................................... 74
- Figure 19 – Peak Echo Dynamics .......................................................... 81
- Figure 20 – Broadband Echo .................................................................. 83
- Figure 21 – Narrowband Echo ................................................................. 83
- Figure 22 – Lithium-Ion Battery Box ....................................................... 95
- Figure 23 – Battery Charger ................................................................. 96
- Figure 24 – Interface Connections .......................................................... 97
1. Disclaimers And Notices
The following information must be read and understood by any user of a Dakota Ultrasonics ultrasonic flaw detector and thickness gauge. Failure to follow these instructions can lead to serious errors in test results or damage to the flaw detector. Decisions based on erroneous results can lead to property damage, personal injury or death. Anyone using this instrument should be fully qualified by their organization in the theory and practice of ultrasonic testing, or under the direct supervision of such a person.

1.1 Specific Warnings.
The DFX-544 contains a high-energy, precision pulser allowing optimum testing results to be obtained by matching the pulse width to the probe characteristics. This circuitry may be damaged by voltage spikes. It is recommended that the instrument be switched off, or the pulser stopped (by pressing the freeze key) before changing probes.

1.2 General Warnings
Proper use of the ultrasonic test equipment requires three essential elements:

A. Knowledge of the specific test or inspection application and applicable test equipment.

B. Selection of the correct test equipment based on a knowledge of the application.

C. Competent training of the instrument operator.
This operating manual provides instruction in the basic operation of the DFX-544 flaw detector. In addition to the methods included herein, many other factors can affect the use of this flaw detector. Specific information regarding these factors is beyond the scope of this manual. The user should refer to appropriate textbooks on the subject of ultrasonic testing and thickness gauging for more detailed information.
1.3 **Operator Training**

Operators must receive adequate training before using this ultrasonic flaw detector. Operators must be trained in general ultrasonic testing procedures and in the set-up and performance required by each specific test or inspection. Operators must understand:

A. Sound wave propagation theory.
B. Effects of the velocity of sound in the test material.
C. Behavior of the sound wave at the interface of two different materials.
D. Sound wave spread and mode conversion.

More specific information about operator training, qualification, certification and test specifications can be obtained from technical societies, industry groups and government agencies. The user is referred to the American Society of Nondestructive Testing at [http://www.anst.org](http://www.anst.org), and the American Welding Society at [http://www.aws.org](http://www.aws.org).

1.4 **Testing Limitations**

In ultrasonic testing, information is obtained only from within the confines of the sound beam as it propagates into the test material. Operators must exercise great caution when making inferences about the nature of the test material outside the limits of the sound beam. The condition of materials can vary significantly and the results can be erratic in the absence of exercising good judgment.

1.5 **Critical Operating Factors**

The following procedures must be observed by all users of this ultrasonic flaw detector in order to obtain proper and accurate results.

A. **Calibration of the Sound Velocity.** An ultrasonic flaw detector operates on the principle of measuring the time of flight of a burst of high frequency sound through the test piece as well as evaluating the amplitude of reflected or
transmitted echoes. The sound velocity of the test piece multiplies this time in order to obtain an accurate distance or thickness reading. Since the actual sound velocity in materials can vary from the published values, the best result is obtained when the instrument is calibrated on a reference block made from the same material as the test piece. This block should be flat, smooth and as thick as the maximum thickness expected of the test piece.

Users should also be aware that the sound velocity might not be constant throughout the test piece due to effects such as heat-treating. This must be taken into consideration when evaluating the results of ultrasonic thickness testing. The calibration should always be checked after testing to minimize errors.

B. Transducer/Probe Zero Procedure. The transducer/probe calibration procedures must be performed as described in this manual. The calibration block must be clean, in good condition and free of noticeable wear. Failure to perform the transducer/probe zero and calibration procedure will cause inaccurate thickness readings.

C. Flaw Detection Calibration. When performing flaw detection, it is important to note that the amplitude of indications is not only related to just the size of the discontinuity. The depth of a discontinuity below the test piece surface will also have an effect on the amplitude due to characteristics of the sound beam spread and near field zone of transducer/probe. In addition, the characteristics of the discontinuity such as orientation and classification can alter the expected amplitude response. For these reasons, calibration should be performed on test blocks made of the same material as the test piece with artificial discontinuities within the range of size and depth in the material to be detected. The user is again cautioned to refer to reference books which are beyond the scope of this manual.

D. Effects of Temperature on Calibration. The sound velocity in test pieces and the transducer/probe wear face changes
with temperature variations. All calibrations should be performed on site with test blocks at or near the same temperature as that expected on the test piece, to minimize errors.

E. **Transducer/probe Condition.** The transducer/probe used for testing must be in good condition, without noticeable wear of the front surface. The specified range of the transducer/probe must encompass the complete range of the thickness to be tested and/or the types of discontinuities to be investigated. The temperature of the material to be tested must be within the transducer/probe’s specified temperature range.

F. **Use of Couplants.** Operators must be familiar with the use of ultrasonic couplants. Testing skills must be developed so that couplant is used and applied in a consistent manner to eliminate variations in couplant thickness which can cause errors and inaccurate readings. Calibration and actual testing should be performed under similar coupling conditions, using a minimum amount of couplant and applying consistent pressure to the transducer/probe.

### 1.6 Disclaimer of Liability

All statements, technical information and recommendations contained in this manual or any other information supplied by Dakota Ultrasonics in connection with the use, features and qualifications of the DFX-544 are based on test believed to be reliable, but the accuracy or completeness thereof is not guaranteed. Before using the product you should determine its suitability for your intended use based on your knowledge of ultrasonic testing and the characteristics of materials. You bear all risk in connection with the use of the product.

Your are reminded that all warranties as to merchantability and fitness for purpose are excluded from the contract under which the product and this manual have been supplied to you. The Seller’s only obligation in this respect is to replace such quantity of the product proved to be defective.
Neither The Seller Nor The Manufacturer Shall Be Liable Either In Contract Or In Tort For Any Direct Or Indirect Loss Or Damage (Whether For Loss Of Profit Or Otherwise), Costs, Expenses Or Other Claims For Consequential Or Indirect Compensation Whatsoever (And Whether Caused By The Negligence Of The Company, Its Employees Or Agents Or Otherwise).

1.7 Electromagnetic Compatibility
This product conforms to the European Directive 89/336/EEC. However, in order to ensure the equipment meets the requirements, the following should be read:

Warning: This is a “CLASS A” product. In a domestic environment, this product may cause radio interference. In which case the user may be required to take adequate measures.

Note: This Product Should Not Be Connected To Cables Greater Than Three (3) Meters In Length. If This Is Necessary, The Installation May Require Further EMC Testing To Ensure Conformity.

For any questions relating to the proper use of this product, please contact the manufacturer at the number indicated on the inside front cover copyright page.
2. How to Use this Manual

This manual has been designed so that a person with a good knowledge of the basics of ultrasonic nondestructive testing may understand the operation and use of the features offered by the DFX-544. The user is advised, however, of the important nature of ultrasonic nondestructive testing and is referred to Section 1 for important information on the proper use of this technology.

Section 3 entitled *Features of the DFX-544*, is a quick reference listing the pertinent characteristics of the instrument and the various functional testing methods that may be used with the instrument.

Section 4 entitled *Fundamentals of Ultrasonic Testing*, will provide a user unfamiliar with the technology of ultrasonic testing a basis for seeking more training and understanding and is a good adjunct to the precautions mentioned in Section 1.

Section 5 entitled *Quick Start*, provides a user familiar with ultrasonic testing a means to operate the instrument’s basic functions and to quickly achieve familiarity without having to understand all of it’s features in detail.

Section 6 entitled *Detailed Operation Instruction*, is an in-depth tutorial describing all of the advanced features of the DFX-544. A study of this section will allow the user to become adept at performing various ultrasonic testing methods with a higher level of productivity than is available with other, conventional ultrasonic flaw detectors.

Section 7 describes important aspects of using and caring for the battery power supply so as to get maximum battery duration time and life.

Section 8 is for users who desire to operate the DFX-544 with ancillary equipment.

The function keys are shown throughout this manual with the mnemonics as shown in Section 5.1, “Front Panel Controls.” A unique help button provides the user with a quick guide and description of the controls.
3. Features of the DFX-544
The DFX-544 is a user-friendly ultrasonic digital flaw detector and thickness gauge, which is simple to use and provides the experienced ultrasonic operator with a full-function device that incorporates many productivity enhancing features. All of the features of the DFX-544 are accessed through a menu system under the control of tactile touch keypads.

3.1 Instrument Characteristics
The main instrument characteristics of the DFX-544 include:

- 110dB Gain Amplifier
- Broad Band Amplifier Testing
- Range From 5mm
- RF (unrectified) Display Mode
- Analog Outputs
- RS232 Output
- Video Output
- Dual Independent Gates
- Context Sensitive Help Screens
- Calibration in Metric, English or Microseconds
- DAC (Distance Amplitude Correction) Curves
- Time Corrected Gain
- AWS/DGS system (option)
- Choice of Color Display or LCD Display
- X- Offset
- Time and Date
- Notes Feature
- Trigonometric Weld Measurement Feature
- Peak Echo Dynamics Mode
- Echo Freeze Mode
- Depth & Thickness Measurement Modes
- Echo to Echo Measurement Mode
- Gate to Gate Measurement Mode
- Thickness Display & Logging
- Thickness Minimum Mode
- Panel Calibration Memories
- A-Scan Memories
- Self Check Feature
- Alpha-Numeric Labelling
- Auto Cal
- Reference Mode
- Signal Contouring
- Signal Smoothing
Functional Testing Methods

The DFX-544 supports the following ultrasonic testing methods:

• Pulse-Echo Flaw Detection
• Transmit-Receive Flaw Detection
• Time of flight measurement
• Contact or Immersion Methods
• Angle Beam (Shear Wave) Testing
• Angle Beam (Surface Wave) Testing
• Crack Diffraction Methods
• Depth of Flaw Measurement
• Single Transducer/probe Thickness Measurement
• Dual Transducer/probe Thickness Measurement
• Indirect Measurement of Sound Velocity in Materials
• Time measurement in microseconds
• Phase change display in unrectified mode
• Through transmission testing
• Creep wave testing
• Pitch and catch techniques
4. Fundamentals of Ultrasonic Testing

The DFX-544 is a single-channel ultrasonic inspection instrument used for the inspection of homogeneous materials for the presence of inclusions, porosity and other discontinuities that could affect the performance of materials and components. It can also be used for thickness gauging of homogeneous materials, requiring access from only one side of the test piece.

High frequency sound waves are introduced into the test material from a transducer/probe that is usually coupled to the test part by water or other suitable liquid coupling. The transducer/probe converts the electrical impulses of the instrument into high frequency sound energy. A short burst of ultrasonic energy is introduced into the test material and some or all of the energy is reflected by discontinuities and/or the far surface of the test part. The reflection of sound energy is a function of the ratio between the acoustic impedance of the discontinuity and the base material. The acoustic impedance of a given material is the product of the density and the velocity of sound in the material. The higher the ratio, the more sound energy that will be reflected. The principle of ultrasonic testing is shown in Figure 1 which shows the ultrasonic energy in the test piece and the resulting instrument display.

Thickness gauging with the DFX-544 operates on the principle of time-of-flight of measurement. This principle utilizes the precise timing of the transit time of a short burst of high frequency sound energy through a material under test. The sound waves travel to the
far side of the test piece and reflect back to the transducer/probe where they are converted into electronic signals and a measurement is obtained. This technique, derived from sonar and radar, has been widely applied to nondestructive inspection and dimensional measurement processes.

4.1 Discontinuity Considerations
The size and geometric shape of the discontinuity relative to the sound beam size and directivity are also factors that affect the sensitivity of the test. As the sound beam enters the material, it spreads and becomes weaker. Therefore, discontinuities farther from the transducer or front surface of the test part produce a lower response from the system. This can be overcome by selectively adjusting the gain of the instrument as a function of distance traveled through the use of the DFX-544’s Time Corrected Gain feature. In addition, discontinuities which present their predominant planar surface to the axis of the sound beam will produce larger reflections than those which only present an edge to the sound beam. Some knowledge of these factors along with an understanding of how discontinuities are formed in the test part are important for the proper use and effectiveness of this instrument.

4.2 Ultrasonic Transducer/probes & Sound Fields
The transducer/probe comprises a piezoelectric ceramic material that generates short bursts of mechanical vibration or sound waves when it is excited by a short electrical pulse from the DFX-544. The frequency of the generated sound waves is far beyond the range of human hearing and can be in the range of 0.1 to 20 MHz. Sound energy at these high frequencies does not travel well through air. For this reason, a coupling which in most cases is liquid, must be used between the transducer/probe and the test piece.

Higher frequency transducer/probes are more sensitive to small discontinuities due to their smaller wavelength. The wavelength is
a function of the frequency and the velocity of sound in the test material according to the following equation:

\[ \lambda = \frac{v}{f} \]

Where:
- \( \lambda \) = wavelength
- \( v \) = velocity of sound in the material
- \( f \) = frequency of the transducer/probe

In addition, higher frequency transducer/probes tend to have better resolution due to shorter energy bursts and the smaller wavelength. Resolution is the ability of a transducer/probe and instrument combination to give distinct and separate indications from discontinuities lying close to one another both laterally and axially. On the other hand, higher frequency sound energy attenuates more and tends to scatter in large grain material, causing a loss of sensitivity in thicker sections of material. Proper ultrasonic testing requires careful selection of the frequency to obtain a desired balance between sensitivity and penetration.

The sound field of a transducer/probe is characterized by a near field and a far field. The near field is the region directly in front of the transducer/probe where the sound energy goes through a series of maxim and minim both axially and radially. Responses from small discontinuities in the near field can be irregular. The far field of the transducer/probe is a region of more regular sound energy variations beginning with the highest maximum and gradually declining to zero. The highest maximum point is known as the near field distance and is represented by \( N \) or \( Y^+_0 \). This is also the natural focus point of the transducer/probe. Figure 2 below demonstrates the axial variations of a typical transducer/probe.
The near field distance is a function of the transducer/probe frequency, diameter, and the sound velocity in the test material according to the following equation:

\[ Y_0^+ = \frac{D^2 f}{4c} \]

Where:
- \( D \) = diameter of the transducer/probe element
- \( f \) = frequency of the transducer/probe
- \( c \) = velocity of sound in the material

Figure 2 – Ultrasonic Energy Field Distribution
Transducer/probes also exhibit a characteristic called beam spread. The sound beam tends to spread as a function of the distance from the transducer/probe as represented in Figure 3 below.

Beam spread is an important consideration when inspecting discontinuities that may be close to geometric features of the test piece such as corners and fillets. Such geometric features can cause erroneous indications at distances where the beam spread is a factor. For flat or non-focused transducer/probes, beam spread is defined as the angle of the –6dB pulse-echo energy response according to the following equation:

\[
\sin\left(\frac{\alpha}{2}\right) = \frac{0.514 c}{f D}
\]

Where:
- \(\alpha\) = angle of beam spread at –6dB
- \(c\) = velocity of sound in the material
- \(f\) = frequency of the transducer/probe
- \(D\) = diameter of the transducer/probe element

It can be seen from this relationship that beam spread can be controlled by selecting a transducer/probe with a combination of higher frequency or larger element diameter.
4.3 **Straight Beam Testing**

Straight beam testing is the introduction of the sound energy normal to the test piece surface utilizing longitudinal or compression waves. A longitudinal wave is one in which the particle motion is in the same direction as the propagation of the wave. Straight beam testing is used for most flaw detection and thickness gauging.

4.4 **Dual Element Testing**

Dual element transducer/probes contain separate transmitting and receiving elements as shown in Figure 4, usually mounted on delay lines with a slight included angle. This design improves near surface resolution by separating the initial pulse from the received echoes and by providing a slight focus of the sound beam. Dual transducer/probes are therefore, suitable for the thickness gauging of pitting and corrosion. Although dual element angle beam transducer/probes are made for special situations, almost all dual element transducer/probes are used for thickness gauging of corrosion.

---

Figure 4 – Typical Dual Element Transducer/probe
When using dual element transducer/probes it is important to follow good practices in the use of the couplant. Any excess buildup of couplant could cause readings that are thicker than actual. This is because the couplant can add to the measured value. When measuring small diameter piping, always place the split in the transducer/probe across the pipe and use only enough couplant to obtain the reading as shown in Figure 5.

The same precautions are true for pitted front surfaces as shown in Figure 6.
4.5 **Angle Beam Testing**

Angle beam testing is the introduction of sound energy at an angle to the surface of the test piece. In most angle beam testing, the wave energy is mode converted from a longitudinal wave to a shear wave by the refraction principle using a transducer/probe as shown in Figure 7. A shear wave is one in which the particle motion is perpendicular to the direction of propagation. Shear waves have lower velocities and correspondingly larger wavelengths than the longitudinal wave. In fact, the velocity of shear waves is almost half that of the longitudinal wave in most materials.

The incident angle necessary to produce a desired refracted wave can be calculated from Snell’s Law as indicated in the following equation:

\[
\frac{\sin \theta_i}{C_i} = \frac{\sin \theta_r}{C_r}
\]

Where:
- \(\theta_i\) = incident angle of the transducer/probe wedge
- \(\theta_r\) = desired refracted angle
- \(C_i\) = sound velocity in the wedge
- \(C_r\) = sound velocity of a shear wave in the test material

The transducer/probe wedge is usually manufactured from a polymer material so that the difference is sound velocity is large enough to produce the desired refraction.
Angle beam or shear wave testing is most often used for the inspection of welds. The reason for this is to be able to position the transducer/probe away from the weld bead yet propagate energy into the weld zone.

Another reason to use angle beam testing on welds is to position the sound beam more normal to the expected discontinuities since the flaws in welds are usually perpendicular to the test surface with the exception of porosity. Figure 8 shows the principles of angle beam weld testing.

Depending on the incident angle, refracted sound beams can also produce components of longitudinal energy, surface wave energy and Lamb wave energy. Although these advanced topics are beyond the scope of this manual, it is important to know that multiple modes can occur simultaneously which may lead to spurious indications. Surface wave inspection can be used to detect cracks on the surface of materials.

**NOTE:** Angle beam testing is a more advanced ultrasonic testing method. The user is advised to seek training and/or supervision in the use of these methods for weld inspection.
4.6 **Immersion Testing**

Immersion ultrasonic testing is used to automate the process and to provide improved reliability for testing and test piece coverage. Immersion testing offers the advantages of more uniform coupling, increased testing speeds and the ability to focus the sound beam. All of these factors can lead to improved sensitivity and reliability.

Most immersion testing uses single element transducer/probes with a focusing lens applied to the front face. This has the effect of concentrating the sound energy for improved sensitivity and resolution. The focal length of an immersion transducer/probe is usually expressed in water distance. The focal length of a given transducer/probe is limited to the near field distance described previously. When the sound beam strikes a test piece, however, the energy is usually focused more sharply, resulting in a reduction of the focal length. The reason for this is the same principle of refraction as described above for angle beam transducer/probes. This re-focusing effect is shown in Figure 10.

*Figure 9 – Immersion Testing Method*
In order to compensate for the shortening of the focal length, the following equation can be used to calculate a correct water path distance from the transducer/probe to the test piece surface:

$$ WP = F - MP \left( \frac{C_m}{C_w} \right) $$

Where:
- $WP$ = water path
- $MP$ = metal path
- $F$ = focal length in water
- $C_m$ = sound velocity in the test material
- $C_w$ = sound velocity in water

In addition to the refraction effect on the focal length, surface curvature can change the focusing distance. Concave surfaces tend to increase the focal distance and spread the sound beam. Convex surfaces tend to refract the sound beam even more and shorten the focal length.
5. Quick Start

5.1 Front Panel Controls

The front panel controls consist of a series of blue and yellow sealed, pressure sensitive, tactile buttons that facilitate the changing of instrument setting and the movement through the menus on the screen. These buttons are described below along with the mnemonics used throughout this manual.

Figure 11 – Front Panel of the DFX-544

When the term “Highlighted” is used, it refers to text with a bright background and dark letters which is the selected item. (Opposite for LCD Display)
<table>
<thead>
<tr>
<th>Button/Mnem</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>![PWR]</td>
<td>“Power On” push button and “Power Off” push button for switching the instrument On and Off. Operates as a toggle. N.B Random lines or characters may be displayed for a second or two after switch on, before the memory is initialized, this is normal.</td>
</tr>
<tr>
<td>![STEP]</td>
<td>Press to select the dB step value of amplifier gain as 0.5, 2, 6, 14, or 20dB. The selected value is indicated at the top right-hand corner of the Gain Box, which is always located at the bottom right side of the screen. This is a momentary button with no repeat.</td>
</tr>
<tr>
<td>![GAINU]</td>
<td>Press to increment or decrement the gain value indicated in the Gain box. This is always located at the bottom right side of the screen. This is a repeat button with acceleration to facilitate quick scrolling of the value.</td>
</tr>
<tr>
<td>![GAIND]</td>
<td>Selects either Reference or Gain settings within the Gain box. When Reference is selected, the increment and decrement buttons will change both the Reference and Gain values together. This is a momentary button with no repeat.</td>
</tr>
<tr>
<td>![REFGAIN]</td>
<td>These buttons move the highlighted cursor along the top of the screen left and right to the sub menu to be selected. These are momentary buttons with no repeat. The parameter boxes on the right of the screen change as the sub menu is selected.</td>
</tr>
<tr>
<td>Button/Mnem</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>OK</td>
<td>This button operates in conjunction with the memory menus to accept a Store or to accept a Recall of a memory already in storage. In the print mode, OK acts as the print button. This button operates in connection with the plain yellow buttons next to the parameter boxes to increase the value or step the selection in the positive direction. In the case of Transducer/probe Zero or Delay, it moves the signals to the right. This is a repeat button with acceleration to facilitate quick scrolling of the value.</td>
</tr>
<tr>
<td>INC</td>
<td>This button operates in connection with the plain yellow buttons next to the parameter boxes to decrease the value or step the selection in the reverse direction. In the case of Transducer/probe Zero or Delay, it moves the signals to the left. This is a repeat button with acceleration to facilitate quick scrolling of the value.</td>
</tr>
<tr>
<td>DEC</td>
<td>This button selects between the two main menus at the top of the screen. The menus are described in Section 6.1 that follows. This is a momentary button with no repeat.</td>
</tr>
</tbody>
</table>
Button/Mnem | Description
---|---
FZ/PK | Press this button once to select Freeze mode for the A-Scan display. This is a useful feature for holding an echo for evaluation. When in this mode, a box is highlighted showing FREEZE below the graticule.

Pressing the button a second time selects Peak mode, which holds and updates all echoes on the display during inspection. This feature allows an envelope or echo dynamic pattern to be drawn on the screen which is useful for angle beam inspection to locate the peak signal. When in this mode, a box is highlighted showing PEAK below the graticule.

Pressing the button a third time selects KEYLOCK mode, preventing accidental changing of parameters.

Pressing the button a fourth time returns the A-Trace display to normal mode. This is a momentary button with no repeat action.

FN | The Function button selects a menu along the top of the display with additional functions not on the start-up menu. The menus are described in Section 6.1 that follows. This is a momentary button with no repeat.

This button selects the help menu which overlays the display. The help menu explains how the DFX-544 operates with a choice of three options:

- UP/RT Using the MS340.
- OK Description of the active menu.
- DN/LT Calibration procedure.

Pressing the HELP button again at any point in the help screens returns the display to normal mode. The Help Screen also displays the Instrument serial number & software version.
Button/Mnem | Description
--- | ---
YBLK | The four yellow buttons on the right side of the display are used to select the menu boxes, which appear on the right side of the A-Trace. When a menu box is selected, it will be highlighted. Some menu boxes contain a single or double arrow point indicating slow or fast adjustment mode. Press the button next to the selected box a second time to toggle between slow and fast modes.

Rx | BNC or Lemo 1 connector is the receiver socket used for twin or dual transducer operation.

Tx | BNC or Lemo 1 connector is the transmitter and receiver socket used for single transducers or as the transmitter only, for twin or dual transducer operation.

AUX | A socket to connect various devices such as an external alarm or other client requirement.

CHARGE | A two-pin socket used to connect the battery charger for recharging the battery pack. A red dot is provided on both the socket and plug to facilitate alignment.

Refer to Section 7 for information on power supplies and charging of the battery pack.

5.2 Panel Calibration Memory

The panel calibration settings of the DFX-544 always remain in memory when the instrument is turned off, even if the battery pack is removed. That is, whatever the calibration settings are just prior to turning the instrument off will be the settings in place the next time the instrument is again turned on.

At times, it may be desirable to start with a “fresh palette” of settings. This is especially true when beginning a new test procedure or going from flaw detection to a thickness gauging procedure. Otherwise, it may be necessary to go through all of the
menus to reset various functions. A reset function is provided to facilitate the returning of all panel calibration settings to the factory defaults.

To reset panel settings to factory defaults:

1. Switch the instrument off.

2. Depress the yellow MEM button and hold while switching the instrument on until the reset display is seen.

3. Press the UP/RT button to reset the instrument to factory defaults.

NOTE: Before performing this procedure, be sure to save any favorite panel calibration settings to memory by using the procedure outlined in Section 6.3 on page 58.

NOTE: Resetting the panel settings restores the instrument to metric measurement mode and PAL video output mode.

Factory default values:

Zero: 0.000
Velocity: 5930 Print: Off Smooth: On
Range: 100 Dist.1: 100.0 Color: 0
Delay: 0.00 Dist.2: 200.0 Bright: 10
Detect: Full Accept: CAL Video: PAL
Reject: 0 Start: 24.80 P_OP: Off
PRF: 1000 Hz DAC: Off Clock: Off
Gates: Off Curve: DAC AWS: Off
Meas: MONITOR Units: Metric DGS: Off**
Angle: 45 Click: On Mode: Single
X_OFF: 0.0 Alarm: Mute

** DGS is optional and may not be fitted
Clearing the memory:
The DFX-544’s memory is comprised of all the stored A-Logs, T-Logs and calibration set-ups. Erasing all of these values accidentally could have far reaching consequences. Should the occasion arise for a need to erase all of the memory, call the factory for instructions.

5.3 Flaw Detection
Perform the following steps to establish a basic flaw detection mode for the DFX-544. Units shown are in inches. For metric units, select METRIC UNITS from the UTIL menu and use the corresponding values for the parameters.

1. Select a suitable transducer/probe, preferably a 5MHz, half inch diameter narrow band.

2. When making a quick adjustment on a menu parameter, press the adjacent yellow button until the double arrow appears next to the parameter name. This establishes the fast scroll using the INC and DEC buttons.

3. In the CAL menu, set the following parameters:
   a) ZERO to 0.000
   b) VEL can be left as it is.
   c) RANGE to 125 or other suitable value to cover the test range of interest.
   d) DELAY to 0.000
   GAIN to 50.0

4. In the AMP menu, set the following parameters:
   a) DETECT to FULL
   b) REJECT to 5
   c) PRF to 1000Hz

5. In the GATE1 menu, set the following parameters:
a) STATE to ON +VE
b) START to 10.0
c) WIDTH to 50 or other suitable value to cover the test range of interest.
d) LEVEL to 50.0

6. In the GATE2 menu, set the STATE to OFF

7. In the MEAS menu, set the following parameters:
   a) MODE to DEPTH
   b) TRIGGER to FLANK
   c) HUD to OFF
   d) T-MIN to OFF

8. In the Function/DAC menu, set the MODE parameter to OFF

You are now prepared to perform basic flaw detection. Using an appropriate calibration block, adjust the GAIN parameter to establish the correct sensitivity. Adjust other parameters as necessary to optimize the calibration. For more in-depth features of the DFX-544, see Section 6.4, “Flaw Testing” on page 62.

5.4 Thickness Gauging

Perform the following steps to establish a basic thickness-gauging mode for the DFX-544. Units shown are in metric. For inch units, select INCHES from the UTIL menu and use the corresponding values for the parameters.

1. Select a suitable transducer, preferably a 5MHz, half inch diameter broadband type.

2. Select an appropriate calibration block with at least three known thickness sections covering the range to be inspected and made from the same material as that of the test piece.
3. When making a quick adjustment on a menu parameter, press the adjacent yellow button until the double arrow appears next to the parameter name. This establishes the fast scroll using the INC and DEC buttons.

4. In the CAL menu, set the following parameters:
   a) ZERO can be left alone
   b) VEL can be left alone
   c) RANGE to 125 or other suitable value to cover the test range of interest.
   d) DELAY to 0.000
   e) GAIN to 50.0

5. In the AMP menu, set the following parameters:
   a) DETECT +VE HW
   b) REJECT to 25 (If required for noise removal.)
   c) PRF to 1000Hz

6. In the GATE1 menu, set the following parameters:
   a) STATE to +VE
   b) START to 10
   c) WIDTH to 50 or other suitable value to cover the test range of interest.
   d) LEVEL to 25.0

7. In the MEAS menu, set the following parameters:
   a) MODE to DEPTH
   b) TRIGGER to FLANK
   c) HUD to ON
   d) T-MIN to OFF
8. Calibrate the thickness readout on the selected calibration block using the procedure in Section 6.5.2, “A-Cal” on page 86.

You are now prepared to perform basic thickness gauging. Adjust parameters as necessary to optimize the calibration. For more in-depth features of the DFX-544, see Section 6.5, “Thickness Gauging” on page 82.

6. Detailed Operation Instruction

Before proceeding with this section, the user should be familiar with the front panel controls described in Section 5.1 on page 20. It is also assumed that the user has a good understanding of the theory and practice of ultrasonic testing.

6.1 Basic Menu Functions

At power on, an information screen is displayed momentarily showing the instrument serial number, program rendition, and software version number while a self-test is performed. After the self-test, the Main menu is displayed above the A-Trace display and the CAL menu is highlighted. The CURL and CURR buttons can be used to move the highlighted cursor through the menu selections.

To the right of the A-Trace are four parameter boxes for the highlighted submenu and the REF/GAIN box that always appears at the bottom right.
6.1.1 Main Menu

The Main menu is the power on default menu and can be reached from the Function menu and the Memory menu by pressing their respective buttons a second time.

CALibration Menu

ZERO  Used to calibrate the screen and thickness readout for zero offsets that are inherently different for each transducer/probe. Units are microseconds in both mm and inch modes.

VEL  Used to calibrate the screen and thickness span readout based on the velocity of sound in the test material. Units are meters per second in mm mode and inches per microsecond in inch mode.

RANGE  Used to set the full screen width of the horizontal A-Trace in mm, inches, or microseconds depending on the Units chosen in the FN UTIL menu. The range is 5mm to 10 meters (.20"-400").

DELAY  Used to set the delay or offset of the left side of the A-Trace for viewing of a portion of a signal. The range is 0 to 10 meters (0-400").
**AMPifier Menu**

**FREQ**  
Used to set the center frequency band of the amplifier to match the transducer/probe. Ranges are 1, 2, 5, 10 & 15MHz narrow bands and 1-35MHz WIDE band.

**DETECT**  
Used to set the video detection and display mode for the desired rectification of the signals from RF, -VE HW (negative half-wave), +VE HW (positive half-wave), and FW (full-wave).

**REJECT**  
Used to remove low level noise from the A-Trace. Reject is linear and is adjustable from 0 up to 80% of full screen height.

**CONTOUR**  
Used to filter or contour the shape of the echo signals, adjustable from 0 or no contouring (hollow) to a level of 6 (filled in).
**TX Transmitter Menu**

**TX WIDTH** Used to adjust the width of the square wave pulser to match the transducer/probe. Adjustable in 10 or 1 ns steps from 20 to 500 ns. Usually set to match the transducer/probe frequency at 1/2 its wavelength. Thus, the nominal settings would be:

- 1 MHz: 500 ns
- 2 MHz: 250 ns
- 5 MHz: 100 ns
- 10 MHz: 50 ns
- 15 MHz: 30 ns
- WIDE: 20 ns

Adjust to optimize the shape and amplitude of echoes.

**DAMPING** Used to set the resistive damping of the transducer/probe to optimize pulse shape versus amplitude. Variable in steps of 33, 50, 100, and 400 Ohms.

**VOLTS** Allows switching between 400 and 200 Volts. Note that in 400V operation the pulse width is limited to a minimum of 100 ns.

**PRF MAX** Used to set the maximum pulse repetition frequency that may be reduced for large values of display range and delay. Selectable values are 35, 63, 150, 250, 500, and 1,000 Hz. Lower values will reduce ghosting and noise echoes.
NOTE
The TX has an overload protection circuit which monitors output power. If the output is overloaded a message is flashed on the display. If this occurs reduce either TX WIDTH, PRF MAX, or increase DAMP. No damage will occur in overload, but the output voltage may be reduced.
**GATE1 & GATE2 Menus**

**STATE** Set the state of the gate as follows:
- **+VE**: The alarm triggers when an echo in the gate exceeds the threshold level.
- **-VE**: The alarm triggers when an echo in the gate falls below the threshold level. Usually used to monitor for loss of back wall echo.
- **EXPAND**: Expands the gate width to fill the horizontal display width. Only applies to gate 1.
- **OFF**: Switches the gate off.

**START** Used to set the start position of the gate relative to the initial pulse. Units are mm or inches and range is from 0 to the full time base of the horizontal display.

**WIDTH** Used to set the width of the gate. Units are mm or inches and range is from 0.15mm (0.001in, 0.05μsec), depending on the range selected, to the full time base of the horizontal display.

**LEVEL** Used to adjust the alarm threshold level, which corresponds to the vertical height on the A-Trace. Adjustable in 0.5% or 2% steps from 0% to 100% full screen height.
MEASurement Menu
In the measurement menu, the top selection box shows the selected measurement mode and the remaining three selection boxes vary depending on the mode selected as follows:

**MONITOR MODE:** In this mode, gates 1 and 2 act as two independent monitor gates.

**DEPTH MODE:** In this mode, gate 1 functions as a depth or thickness monitor and displays the depth (D:) and height (H:) of the first signal after the start of the gate that reaches or exceeds the gate level threshold. Values are displayed in a highlighted box below the A-Trace.

**TRIGGER** Used to select the depth or thickness measurement to the FLANK (left edge) or PEAK of the first echo after the start of the gate.

**HUD** When turned ON, provides a large, Head-Up Display of the depth or thickness reading at the top right of the A-Trace. Only available in DEPTH and E-E modes. In DEPTH mode, the amplitude is also displayed up to 100%. The INC button sequences the selection from distance to amplitude to off.

**T-MIN** When turned ON, the depth or thickness reading will freeze that last minimum or lowest value measured. To reset, toggle the function to OFF and then ON. Only available in the DEPTH mode.
E-E MODE: In this mode, gate 1 functions as a thickness monitor and measures the thickness between the first signal in the gate and the second signal in the gate that reaches or exceeds the level threshold. A second bar is shown representing the blanking (see BLANK).

BLANK This function sets the blanking distance, as a percentage of the total gate width, which is a blind zone after the first echo, after which a second echo can be measured. This helps to eliminate undesired noise in the first echo from being measured, as thickness but will limit the minimum thickness capability if set too large.

G-G MODE This is similar in concept to E-E mode, but uses gates 1 & 2, allowing the thresholds for the two gate measurements to be completely independent,

TRIG MODE: The TRIGonometry mode is used with angle beam transducer/probes for weld inspection to calculate the three important measurements based on the echo position: the Beam path distance (\( \alpha \):), the Surface distance (\( \rightarrow \):), and the Depth distance (\( \downarrow \):) from the index point of the transducer/probe.

THICK Set to the thickness of the material being tested to account for multiple skips of the angled sound beam in the test material.
PROBE Menu

**TX MODE**  Used to set the transmit-receive mode for single or double element transducer/probes. Double element transducer/probes have separate transmit and receive elements whereas single element transducer/probes use one element for both transmit and receive.

**ANGLE**  Set to the nominal refracted angle of the transducer/probe to calibrate the Surface and Depth measurements.

**X-OFFSET**  Used to enter the distance from probe emission point to front of probe case. This is used by the TRIG function in MEAS menu to give the surface distance.

When highlighted, this cursor allows a second main menu to be selected by pressing the CURR control.

When highlighted, this cursor allows return to the first main menu by pressing the CURL control.
PRINT Menu
This menu allows printing of information to a suitable serial printer connected to the RS232 serial port on the DFX-544. Please note that this requires a printer with a serial port.

OFF  The PRINT mode is switched OFF

DISPLAY  With the Print mode in Display, the screen display will be sent to the printer when the OK button is pressed.

LIST CPY  With the Print mode in List Copy, all the calibration settings, the screen and all notes in the Edit feature will be sent to the printer display when the OK button is pressed.

A_LOG  In the A-Log print mode, all of the stored A-Scans that are valid will be printed when the OK button is pressed, along with the calibration settings and notes. This can take considerable time if all 100 A-Scans are stored.
6.1.2 Function Menu

Press the FN button to access the Function menu. Press it again to return to the Main menu. When moving in and out of the Function menu, the position of the cursors in the Main menu remains in their previous positions.

A-CAL Menu

This menu provides automatic calibration of sound velocity and transducer/probe zero. Gate 1 is used to select the reference echoes. The calibration procedure is described fully in Section 6.5.2 on page 86.

DIST1 The actual distance to the first or thinnest reference echo in the calibration block.

DIST2 The actual distance to the second or thickest reference echo in the calibration block.

ACCEPT After pressing OK to accept DIST1 and DIST2. Press OK when ACCEPT CAL is highlighted

START Used to adjust the start of the gate to assure that the first and second echoes are measured.
**DAC Distance Amplitude Correction Menu**

This menu is used to create DAC curves using a series of reference echoes. Once drawn, the DAC curve acts as an alarm threshold level for the gate where the level varies to match the attenuation and field characteristics of the transducer/probe and test material combination. The calibration procedure is described fully in Section 6.4.2 on page 66.

**ON MODE:** Displays the DAC curve on the screen.

**CURVE** Used to display the DAC curve alone or with -6/-12 dB reference curves or -6/-14 dB reference curves.

**TRIGGER** Used to select alarm level threshold for the DAC curve, or the -6dB curve or the -14/-12 dB curve or the gate.

**MEAS** Used to select the measurement value in dB, % fsh or %DAC for any signal that is in the curve or gate.

**DRAW MODE:** Used to create the DAC curve.

**CURSOR** Used to move the cursor over the reference echo for which a DAC point is being set.

**POINT** Display only. Shows the last point created after pressing the OK button.
TCG Time Corrected Gain Menu
This menu is used to create TCG curves using a series of reference echoes. Once drawn, the TCG curve acts as swept gain control on the amplifier to set different gain levels relative to distance. The calibration procedure is described fully in Section 6.4.3 on page 69.

**ON MODE:** Activates the TCG curve to adjust the gain. Can be activated in RF or rectified display modes.

**CURVE** When switched ON, the TCG curve is displayed.

**DRAW MODE:** Used to create the TCG curve. Cannot be drawn in RF display mode.

**CURSOR** Used to move the cursor over the reference echo for which a TCG point is being set.

**POINT** Display only. Shows the last point created after pressing the OK button.
AWS Menu
This menu is used when performing weld inspection in accordance with the American Welding Society’s Structural Welding Code, ANSI/AWS D1.1-94. It provides a convenient method to automatically calculate the Indication Rating as defined in the code. The calibration procedure is described fully in Section 6.4.5 on page 75.

SET MODE: Used to set up the AWS measurement mode.

REF Used to set the Indication Level.

CURSOR Used to move the cursor over the reference echo to set the reference level.

MEAS MODE: Used to make measurements in accordance with the code.

IL dB The dB required setting the indication to the reference level.

AF dB The attenuation factor to correct for the depth of the indication.

IR dB The indication rating calculated in accordance with the code. Also the difference the IL and the reference level with correction for attenuation.

DGS / AVG
For information on use of the DGS method and associated menus refer to the supplemental manual supplied with this option.
UTILities menu

UNITs Selects INCHES, $\mu$s, or METRIC measurement units. Microseconds, $\mu$s, is a useful mode when using Time of Flight Diffraction techniques (TOFD). When in $\mu$s mode, the Velocity is fixed at 2000 m/s (5000 in/$\mu$s) and is not adjustable.

CLICK When on, a beep will sound to confirm each button press.

ALARM When set to AUDIBLE, a buzzer will sound during any gate alarm.

SMOOTH When switched on the signal is displayed as an envelope, this can help interpretation on long ranges.
**VIDEO Menu**

**COLOR**  
*(Color Display)*
Selects one of eight Color schemes for the display.

**BAKLIGHT**  
*(LCD display)*
Turns the backlight on or Off, Using the backlight improves visibility in poor lighting, but significantly increases power consumption, reducing battery life.

**BRIGHTness**  
*(Color Display)*
Controls the display brightness. The level selected will affect the battery duration. A value of 1 gives about 10 hours, whereas a value of 20 will give about 5 hours of operation, assuming the battery is in good condition and at room temperature.

**CONTRAST**  
*(LCD)*
Adjusts the display contrast for best visibility.

**VIDEO**
Select NTSC (USA) or PAL (UK/Europe) composite video output modes. The screen update rate is 50Hz in PAL and 60Hz in NTSC. NTSC mode will be slightly brighter.

**GRATICULE**
Selects different graticules from **OFF**-no graticule.  
**FULL** - a complete 100% graticule.  
**SPARSE** - a row of dots at 10% intervals.  
**50%** - divisions at 50% full screen height.  
**50%+** - larger 10% width divisions.  
**50%++** even larger 10% width divisions.
**P_O/P** Proportional Output Control Menu

This menu controls the analog and digital proportional outputs. Two outputs are provided one for depth and one for amplitude. The outputs are active when the associated gate is triggered. Switching on the outputs will reduce battery duration. Set to OFF when not being used.

Note: On the Color model, a right facing carat shows a further menu CLOCK.

| MODE: OFF | Outputs switched off |
| MODE: O/P | Outputs updated at 100-120 Hz, depending on Video mode selected. When selected, the signal resolution and measurement accuracy is reduced. |

| O/P 1 | Select depth output for DEPTH1 (Gate1), DEPTH2 (Gate2), or E1-E2, the distance between the two depth measurements. |
| O/P 2 | Select the amplitude output for LEVEL1 (Gate1), LEVEL2 (Gate2), or L1-L2, the difference between the two amplitudes. |

| TRIGGER | Sets the depth output to trigger on echo PEAK or echo FLANK, the same as for measurement readout. |

When highlighted, this cursor allows a second FN menu to be selected by pressing the CURR button.

When highlighted, this cursor allows return to the first FN menu by pressing the CURL button.
**CLOCK Menu**

Note: This is an extension of the P_O/P menu on the Color display model.

- **TIME MODE:** Used to set the current time.
  - HOURS: Used to set the current hour in 24-hour format.
  - MINS: Used to set the current minutes.
  - DATE: Used to set the current date. (Selected by pressing TIME key, then DEC)

- **DATE MODE:** Used to set the current day number.
- **MONTH:** Used to set the current month number.
- **YEAR:** Used to set the current year.

NOTE: Be sure to press OK to save the new CLOCK settings.
6.1.3 Memory Menu
Press the MEM button to access the Memory menu. Press it again to return to the Main menu. When moving in and out of the Memory menu, the positions of the cursors in the Main menu remain in their previous positions.

**PANEL** Setup Menu
This menu provides storage and recall of up to 20 calibration setting. The use of this feature is described fully in Section 6.3 on page 58.

- **STORE** Used to select a storage location (1-20).
- **RECALL MODE:** Used to recall a stored calibration set to the active memory. Press OK to recall.
- **DELETE MODE:** Used to delete a VALID (used) calibration set. Press OK to delete. Press OK again after the confirmation prompt.
- **LIST MODE:** Shows the notes associated with the stored calibration set. Pressing OK will recall the calibration set at which time the Notes can be edited.
- **STORE MODE:** Stores the current calibration settings in memory to the selected Store set. Press OK to store. Press OK again after the confirmation prompt.
- **INDEX MODE** Lists all memories, use INC & DEC to change ‘page’. Cancelled by scrolling past the end
- **STATE** Display only. VALID indicates that the store location is used. EMPTY indicates that it is not used. To change VALID to EMPTY, use the DELETE function.
The EDIT NOTES function is used to edit the notes in the current calibration set in memory (it is not the one in the selected Store). Data can be edited via the keypad or via the Dakota Ultrasonics keyboard.

These are the steps to follow if the keyboard is connected.

<table>
<thead>
<tr>
<th>KEYBOARD FUNCTION</th>
<th>Connect the keyboard to the AUXilary socket on the front panel of the set. The connector is a 5pin one. Press EDIT NOTES from the keypad to enter the keyboard function.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPITAL CHARACTER &amp; NUMBERS</td>
<td>Press any key on the keyboard to edit the capital characters, the same applies to numbers.</td>
</tr>
<tr>
<td>SMALL CHARACTER &amp; SIGNS</td>
<td>Press SHIFT + the wanted character or sign.</td>
</tr>
<tr>
<td>INSERT A SPACE</td>
<td>Press the SPACE KEY to insert a blank character at the position the cursor is currently on.</td>
</tr>
<tr>
<td>DELETE CHARACTER</td>
<td>Press the Back-Space KEY to delete the previous character to the position the cursor is currently on.</td>
</tr>
<tr>
<td>DELETE CHARACTER</td>
<td>Press DEL KEY to delete the character under the cursor</td>
</tr>
<tr>
<td>NEXT LINE</td>
<td>Press ENTER KEY to move cursor to the next line.</td>
</tr>
<tr>
<td>UP ARROW</td>
<td>Press the ( \uparrow ) KEY to move the cursor up.</td>
</tr>
<tr>
<td>DOWN ARROW</td>
<td>Press the ( \downarrow ) KEY to move the cursor down.</td>
</tr>
</tbody>
</table>
LEFT ARROW  Press the ← KEY to move the cursor left.

RIGHT ARROW  Press the → KEY to move the cursor right.

END OF LINE  Press the End KEY to move the position of the cursor to the end of line.

HOME  Press the Home KEY to move the cursor to the initial position.

Ctrl  Press the Ctrl KEY to clear the screen.

EXIT  Press the Esc KEY to exit back to the PANEL or A-LOG menu. Store the calibration set to save the notes.
If the keypad is used to enter data then:

EDIT NOTES: Press to bring up the editing boxes as follows:
Use the CURL and CURR buttons to move the cursor horizontally along a text line. Use the UP/RT and DN/LT buttons to highlight a character from the map. Press OK to write a character to a line and press MEM to clear all text.

NEXT LINE Press to scroll through and select a line for editing.

INSERT CHAR Inserts a blank character space before the one the cursor is currently on.

DELETE CHAR Deletes the character under the cursor.

EXIT Exits back to the PANEL or A-LOG menu. Store the calibration set to save the notes.

--- NOTES ---
LABEL :
OPERATOR:
LOCATION:
PROBE :
NOTES :

0 1 2 3 4 5 6 7 8 9 : = . / % *
; , - + = ? A B C D E F G H I J
K L M N O P Q R S T U V W X Y Z

CURSOR EDIT CLEAR ALL

Edit Notes Window

(Typical for the PANEL and A-LOG menu)
A-LOG Menu
This menu provides storage and recall of up to 100 A-Scans with settings. The use of this feature is described fully in Section 6.4.6 on page 77.

STORE Used to select a storage location (1-100).

RECALL MODE: Used to recall a stored A-Scan and settings to the active memory. Press OK to recall. The display comes up in FREEZE mode. Press FZ/PK to remove.

DELETE MODE: Used to delete a VALID (used) A-Scan and its settings. Press OK to delete. Press OK again after the confirmation prompt.

LIST MODE: Shows the notes associated with the stored A-Scan and its settings. Pressing OK will recall the calibration set at which time the Notes can be edited.

INDEX MODE: Lists all memories, use INC & DEC to change ‘page’. Cancelled by scrolling past the end

STORE MODE: Stores the current A-Scan and its settings in memory to the selected Store set. Press OK to store. Press OK again after the confirmation prompt.

STATE Display only. VALID indicates that the store location is used. EMPTY indicates that it is not used. To change VALID to EMPTY, use the DELETE function.

EDIT: (See notes editing summary in PANEL above.)
**REF Menu**

This menu allows a waveform stored in A-LOG memory to be displayed as a reference on the display. Before a waveform can be recalled, it must be stored in an A-LOG location.

**STORE**  Used to select a storage location (1-100).

**RECALL MODE:**  Used to recall a stored A-Scan and display it. Press OK to recall.

**LIST MODE:**  Shows the notes associated with the stored A-Scan. Pressing OK will recall the waveform.

**OFF MODE:**  Used to remove a Reference waveform. Set MODE to OFF, and press OK.

**STATE**  Display only. VALID indicates that the store location is used. EMPTY indicates that it is not used.
T-LOG Menu

This menu provides storage and recall of up to 2,000 thickness readings. Numeric and Sequential modes are available as selected in the T-FN menu. This feature is described fully in Section 6.5.4 on page 89.

Numeric Mode: Readings are stored under a three level code, starting with BLOCK (1-14), followed by LOCATION (1-2000) and NO (1-2000).

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>Used to select the block number (1-14) for storage or viewing of a thickness reading.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC</td>
<td>Used to select the location number for storage or viewing of a thickness reading.</td>
</tr>
<tr>
<td>NO</td>
<td>The individual thickness reading number into which a thickness reading is stored. Increments automatically when storing a reading by pressing the OK button.</td>
</tr>
<tr>
<td>THICK</td>
<td>The thickness reading stored in the BLOCK-LOC-NO. If blank, there is no stored thickness in that particular three level code.</td>
</tr>
</tbody>
</table>
Sequential Mode: Readings are stored by LOCation (1-2000) number only. In this mode location and historical thickness data can be downloaded to the DFX-544 from a computer, a fixed series of four notes can be added to a location, and any of the 20 PANEL store settings can be assigned to a location.

Note: The HUD is on automatically in sequential mode.

<table>
<thead>
<tr>
<th>LOC</th>
<th>Used to select the location number for storage or viewing of a thickness reading.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>THICK</td>
<td>The thickness reading stored in the LOC. If blank, there is no stored thickness in that number.</td>
</tr>
<tr>
<td>0.334</td>
<td></td>
</tr>
<tr>
<td>NOTES</td>
<td>One of four notes can be selected or blank. OBSTRC for obstruction, PITTING, POOR S/C for poor signal or Couplant, and NO BWE for no back wall echo.</td>
</tr>
<tr>
<td>OBSTRC</td>
<td></td>
</tr>
<tr>
<td>AUTO SET</td>
<td>Allows selection of the auto calibration feature if the downloaded sequence contains PANEL store numbers. The DFX-544 can then be automatically calibrated to one of twenty panel settings for selected sequence numbers.</td>
</tr>
<tr>
<td>ON</td>
<td></td>
</tr>
<tr>
<td>REF 37.5</td>
<td></td>
</tr>
<tr>
<td>GAIN 2</td>
<td></td>
</tr>
<tr>
<td>53.5</td>
<td></td>
</tr>
</tbody>
</table>
**T-FN Menu**

**PRINT MODE:** Set the mode to PRINT to print the selected blocks and locations to the printer on the RS232 port.

**DELETE MODE:** Set the mode to DELETE to delete the selected blocks and locations. Press OK again after the confirmation prompt.

**BLOCK** Used to select the block number for printing or deletion. Decrement below 1 to select ALL blocks for printing or deletion.

**LOC** Used to select the location number for printing or deletion. Decrement below 1 to select ALL locations for printing or deletion.

**ID MODE** Select NUMERIC or SEQUENCE Mode for Data logging
## 6.2 Menu Tree

<table>
<thead>
<tr>
<th>Menu</th>
<th>Sub-Menu</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>CALibration</td>
<td>ZERO VEL RANGE DELAY</td>
</tr>
<tr>
<td></td>
<td>AMPlifier</td>
<td>FREQ DETECT REJECT CONTOUR</td>
</tr>
<tr>
<td></td>
<td>TXtransmitter</td>
<td>TXWIDTH DAMPING TXVOLTS PRF MAX</td>
</tr>
<tr>
<td>GATE1</td>
<td>STATE</td>
<td>START WIDTH LEVEL</td>
</tr>
<tr>
<td>GATE2</td>
<td>STATE</td>
<td>START WIDTH LEVEL</td>
</tr>
<tr>
<td>MEASurement</td>
<td>↓MODE↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MONITOR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DEPTH</td>
<td>TRIGGER HUD T-MIN</td>
</tr>
<tr>
<td></td>
<td>E-E</td>
<td>TRIGGER HUD BLANK</td>
</tr>
<tr>
<td></td>
<td>G-G</td>
<td>TRIGGER HUD</td>
</tr>
<tr>
<td></td>
<td>TRIG TRIGGER</td>
<td>THICK</td>
</tr>
<tr>
<td>PROBE</td>
<td>TX MODE</td>
<td>ANGLE X_OFFSET</td>
</tr>
<tr>
<td>PRINT</td>
<td>↓MODE↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DISPLAY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LIST CPY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A-LOG</td>
<td></td>
</tr>
<tr>
<td>FN A-CAL</td>
<td>DIST1</td>
<td>DIST2 ACCEPT START</td>
</tr>
<tr>
<td>DAC</td>
<td>↓MODE↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ON CURVE TRIGGER MEAS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DRAW CURSOR POINT</td>
<td></td>
</tr>
<tr>
<td>AWS</td>
<td>↓MODE↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SET REF CURSOR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MEAS IL dB AF dB IR dB</td>
<td></td>
</tr>
<tr>
<td>TCG</td>
<td>↓MODE↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ON CURVE</td>
<td></td>
</tr>
<tr>
<td>Menu</td>
<td>Sub-Menu</td>
<td>Parameters</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td>DRAW</td>
<td>CURSOR POINT</td>
</tr>
<tr>
<td>UTILities</td>
<td>UNITS CLICK</td>
<td>ALARM SMOOTH</td>
</tr>
<tr>
<td>VIDEO</td>
<td>COLOR / BRIGHT</td>
<td>BRIGHT / CONTRAST VIDEO</td>
</tr>
<tr>
<td></td>
<td>VIDEO GRATICULE</td>
<td></td>
</tr>
<tr>
<td>P_O/P</td>
<td>MODE O/P1 O/P2</td>
<td>TRIGGER</td>
</tr>
<tr>
<td>CLOCK</td>
<td>SET TIME</td>
<td>HOURS MINS</td>
</tr>
<tr>
<td></td>
<td>DATE DATE MONTH</td>
<td>YEAR</td>
</tr>
<tr>
<td>MEM</td>
<td>PANEL STORE</td>
<td>↓MODE↓ STORE STATE EDIT*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RECALL STATE EDIT*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DELETE STATE EDIT*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LIST STATE</td>
</tr>
<tr>
<td>A-LOG</td>
<td>STORE</td>
<td>↓MODE↓ STORE STATE EDIT*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RECALL STATE EDIT*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DELETE STATE EDIT*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LIST STATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INDEX STATE</td>
</tr>
<tr>
<td>REF</td>
<td>STORE</td>
<td>↓MODE↓ RECALL STATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OFF STATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LIST STATE</td>
</tr>
<tr>
<td>T-LOG (NUM)</td>
<td>BLOCK LOC NO</td>
<td>THICK</td>
</tr>
<tr>
<td>T-LOG (SEQ)</td>
<td>LOC THICK NOTES</td>
<td>AUTOSET</td>
</tr>
<tr>
<td>T-FN</td>
<td>↓MODE↓ PRINT</td>
<td>BLOCK LOC NUM/SEQ</td>
</tr>
</tbody>
</table>
6.3 **Storage & Recall of Calibration Setups**

After the DFX-544 has been properly calibrated for a particular testing scheme, it is possible to store all of the panel settings for subsequent recall when performing the same test at a later time. Although the last panel settings are “remembered” by the DFX-544’s memory, this feature is useful when the instrument is being used for many different tests requiring substantially different panel calibration settings. In addition to the panel settings, a freeform note can be stored with the panel set that includes provision for a label, an operator name or number, a location identifier, and a transducer/probe identifier. It is possible to store up to twenty sets of panel settings; each assigned a set number from one to twenty. A set of panel settings can be printed after the set is recalled to active memory by using the LIST CPY function in the PRINT menu.

**To store a panel set:**

1. Press the MEM button to access the Memory menu.
2. Use the CURL and CURR buttons to highlight the PANEL menu.
3. If it is desired to store Notes with the panel settings, see the description for entering notes below.
4. Select the STORE box and, using the UP/RT and DN/LT buttons, select a desired STORE number from one to twenty. Note that as the STORE number is changed, the STATE parameter indicates if the number is used (VALID) or EMPTY.
5. Select the MODE box and using the UP/RT and DN/LT buttons, select the STORE mode.

6. Press the blue OK button to store the panel settings.

7. If you forgot to enter Notes, create the Notes as described below and the re-save the panel settings starting at step 5 above.
To recall a panel set:

Follow the above procedure but set the MODE parameter to RECALL and then press the blue OK button.

To delete a panel set:

Follow the above procedure but set the MODE parameter to DELETE and press the blue OK button.

Adding NOTES to PANEL and A-LOG sets:
When storing panel calibration settings or waveforms, it is often useful to add some notes to the set so it can later be identified, or to help the user recall the correct set. This is possible in the PANEL and A-LOG menus by using the NOTES feature.

When a panel calibration set or waveform is to be stored, first calibrate the instrument as desired, or capture the waveform by pressing the yellow FZ/PK button. Then select the EDIT NOTES box in the menu and notice that the window shown below overlays the display area.

The LABEL line is 8 characters long, and is used by the WAVESTORE interface program as a file name for storing to disk. The OPERATOR, LOCATION and PROBE lines are 25 characters each, while the three NOTES lines allow up to 75 characters.

The blue CURL and CURR buttons are used to move the cursor from right to left along a line of text. The yellow button adjacent to the NEXT LINE box is used to advance the cursor down to the next line. When the cursor is at the bottom line, the NEXT LINE function moves it back to the top line.

To delete a character, position the cursor over it and press the yellow button adjacent to the DELETE CHAR box. To clear all of the text in the NOTES window, press the yellow MEM button.

To insert a character space, position the cursor to the right of the desired insert location and press the yellow button adjacent to the INSERT CHAR box.
To select a character from the character map below the Notes lines, use the yellow UP/RT and DN/LT buttons to move the highlight through the map. The press the yellow OK button to add the character to the NOTES lines at the position of its cursor.

As an alternative The Dakota Ultrasonics Keyboard may be used to enter NOTES as described in the Panel section 6.1.3.

Once the desired notes have been added or edited, press the yellow button adjacent to the EXIT box. The text is now entered but not stored. It is now necessary to store the notes using the methods outlined in the PANEL and A-LOG sections.

If a stored PANEL or A-LOG is recalled, its notes will be loaded into the window. The notes can then be viewed and edited using the same procedure detailed above.

---

**Edit Notes Window**

*(Typical for the PANEL and A-LOG menu)*

**NOTE:** When notes are displayed, the menu cursor buttons are disabled. Exit the Notes window to change to another menu.
6.4 Flaw Testing

6.4.1 Basic Flaw Testing

Reliable flaw detection requires three important considerations: a) proper transducer/probe selection, b) an accurate reference block of the same material as that being tested with reference holes representing the orientation and sensitivity desired, and c) proper calibration of the instrument. The following are the basic guidelines for accurate flaw detection but the user is referred to Section 1.3 on Operator Training for advice on seeking in-depth training.

Transducer/probes used for flaw detection are usually of the narrow band variety to provide the best possible sensitivity to the anticipated discontinuities. In some cases, broadband varieties are chosen to optimize near or far surface resolution – the ability to separate discontinuities from the front surface or back surface echo. In either case, the frequency is chosen so that the wavelength in the material is optimized for the orientation and size of expected discontinuities. The single element contact transducer/probe is used for general-purpose flaw detection. The angle beam transducer/probe is used for weld inspection, which is covered in Section 6.4.4 on page 72, and Section 6.4.4 on page 72. Other specialty transducer/probes including dual and surface wave can be used but these topics are beyond the scope of the manual.

The next requirement for reliable flaw detection is a calibration or reference block. This block should be made of the same material as the parts to be inspected. In other words, it should have the same sound velocity and attenuation characteristics. The calibration block should have surfaces that mimic the parts to be inspected so that attenuation and sensitivity characteristic is similar. Most importantly, the calibration block should have a series of fabricated discontinuities representing those expected to found in the test piece. That is, the size and orientation of the
fabricated discontinuities should match the expected natural discontinuities in the test piece. In some cases this may mean flat bottom holes perpendicular to the test surface, side drilled holes parallel to the testing surface, or in some cases, narrow notches representing planar surfaces parallel or perpendicular to the testing surface. Fabricated discontinuities must also be placed near the front and back surface of the calibration block to verify resolution of the transducer/probe and instrument setting combination.

Finally, it is necessary to establish the proper calibration of the DFX-544 in order to assure reliable flaw detection. The essence of this calibration is to set the Pulser, amplifier and gate parameters to provide the necessary sensitivity and resolution. The following are the essential steps for basic flaw detection:

1. Select the appropriate single element contact transducer/probe and calibration block that matches the material and expected discontinuities under test.

2. In the CAL menu, select the proper Range and Delay so those echoes from the expected material depth can be viewed.

3. From the AMP menu, set the Frequency to the nominal value of the transducer/probe and set the detection mode to RF.

4. In the TX menu, set the Mode to Single.

5. Couple the transducer/probe to the calibration block and obtain an echo from a fabricated discontinuity or the back surface and adjust the Gain to set the peak of the echo to about 80% screen height.
6. From the TX menu, adjust the TX Width parameter so as to obtain the maximum amplitude from the echo while optimizing the symmetrical shape of the echo. Figure 12 below shows the proper echo shape while Figure 13 indicates an improper setting of the TX Width.

7. From the TX menu, adjust the Damping parameter to obtain desired echo shape and width for the near surface resolution desired. Check the resolution on a fabricated discontinuity in the calibration block that is near the front surface.

8. From the AMP menu, set the Detect parameter to FW and the Contour parameter to a value to obtain the desired “filling” of the echo. Set the Reject parameter to zero or some small value up to 10 to eliminate noise from the baseline. Do not set the Reject parameter so high as to preclude the detection of small echoes from discontinuities.

9. Adjust the gain to set a reference echo from mid thickness of the calibration block to about 80% amplitude.
10. From the GATE1 menu, set the gate to ON +VE and adjust the Start and Width so that the gate encompasses the full testing range of interest. Place the transducer/probe over the near and far reference reflectors in the calibration block to verify proper coverage. Adjust the Level parameter to 50%.

11. From the MEAS menu, set the Mode parameter to MONITOR and the Trigger parameter to PEAK.

For weld inspection using an angle beam transducer/probe, follow the instructions in Section 6.4.4 on page 72.

For storage and printing of A-Scans, refer to Section 6.4.6, “
6.4.2 **DAC Operation**

Distance Amplitude Correction curves act as monitoring gate triggering thresholds to compensate for attenuation and sound beam characteristics. When properly established, the DAC curve will provide consistent alarming from discontinuities of equal relative size at different depths in the test piece. Functionality is provided to automatically draw 6dB and 14dB or 6dB and 12dB reference curves below the calibrated curve.

It should be noted that since the DAC function only provides a dynamic alarm threshold capability, the dynamic range is limited to about 16dB. Therefore, for materials that attenuate more than 16dB over the depth range of interest, DAC should not be used. Instead, the TCG function may be more applicable. See Section 6.4.3 on page 69 for the use of the Time Corrected Gain feature.

Proper use of the DAC feature requires a reference block made from the same material as that being examined, with flat-bottom or side-drilled holes of the desired size placed at depths covering the range to be inspected.

To establish a DAC curve, follow the following instructions:

1. Establish the basic calibration of the DFX-544 using the desired transducer/probe and the proper reference block.

2. From the FN menu, select the DAC feature.

3. Select the MODE parameter by pressing the yellow button next to it and use the INC button to select DRAW. The other parameters will now be CURSOR and POINT. Note: When in the MODE parameter, only press the DEC button to turn the DAC off. This will erase any logged echoes.

4. The DAC system is now ready to accept reference points. Position the transducer/probe to give a maximum echo from the first or topmost reference hole in the reference block. Be
careful to use a consistent amount of coupling and transducer/probe pressure.

5. Use the INC and DEC buttons to position the bright cursor bar over the echo from the reference hole.

6. Press the OK button to accept the point. A small square will appear as a reference point on the display showing the peak of the signal just recorded.

7. Repeat steps 5 and 6 for each additional reference hole in the reference block, being careful to be consistent with the amount of coupling and transducer/probe pressure. A maximum of ten (10) points can be recorded for a DAC curve.

8. Press the yellow button adjacent to MODE and use the DEC button to select ON mode. The DAC curve will now be

![Figure 14 – Cursor Selection of Echoes for DAC](image)
displayed and the other parameters will change to CURVE and TRIGGER

9. Use the CURVE parameter and the INC button to select just the DAC reference curve, the DAC curve along with the -6dB and -12dB curves, or the DAC curve along with the -6dB and -14dB curves. These additional, automatically generated reference curves provide a means for evaluating discontinuities smaller than those in the reference block.

10. Use the TRIGGER parameter to establish the alarm trigger from the DAC curve, the -6dB curve, or the -12dB/-14dB curve. The latter being whichever one is selected in the CURVE parameter.

If depth measurement is switched on with the DAC feature, the depth mode display below the A-Trace will show the distance to the echo peak and the relative amplitude to the DAC reference curve in dB. Note that the relative dB display is dependent on the REF gain setting, but not the GAIN setting.

To turn off the DAC feature, select the MODE parameter from the DAC menu and press the DEC button until OFF is indicated.
6.4.3 TCG Operation

The Time Corrected Gain feature provides a means of creating an attenuation curve that sets the gain in a swept manner as a function of transit time. A properly constructed TCG curve will compensate for material attenuation and sound beam characteristics so that discontinuities of equal relative size at different depths in the test piece will give an equal amplitude response on the display.

Proper use of the TCG feature requires a reference block made from the same material as that being examined, with flat-bottom or side-drilled holes of the desired size placed at depths covering the range to be inspected.
To establish a TCG curve, follow the following instructions:

1. Establish the basic calibration of the DFX-544 using the desired transducer/probe and the proper reference block.

2. From the FN menu, select the TCG feature.

3. Select the MODE parameter by pressing the yellow button next to it and use the DEC button to select DRAW. The other parameters will now be CURSOR and POINT.

4. The TCG system is now ready to accept reference points. Position the transducer/probe to give a maximum echo from the first or topmost reference hole in the reference block. Be careful to use a consistent amount of coupling and transducer/probe pressure.

5. Use the INC and DEC buttons to position the bright cursor bar over the echo from the reference hole.

6. Press the OK button to accept the point. The POINT parameter will then increment to indicate the next point. As each point is entered, the gain will change to place the echo at about 80% amplitude.

7. Repeat steps 5 and 6 for each additional reference hole in the reference block, being careful to be consistent with the amount of coupling and transducer/probe pressure. A maximum of ten (10) points can be recorded for a DAC curve.
8. Press the yellow button adjacent to MODE and use the DEC button to select ON mode. The TCG curve will now be displayed, the amplifier gain will now swept, and the other parameters will change to CURVE.

9. Use the CURVE parameter and the INC button to select ON or OFF for the display of the TCG curve.

**NOTE:** A TCG curve cannot be drawn while in RF display mode (DETECT-RF), but can be activated. Therefore, if TCG is desired in RF display mode, draw the curve in rectified mode first and then switch to RF. It should be noted that the range of TCG is limited only by the dynamic range of 40dB.
6.4.4 **Weld Inspection Using Trigonometry Mode**

The Trigonometry Mode provides a convenient method for measuring the location of discontinuities when inspecting welds with angle beam transducers. Essentially, the trigonometry mode uses the thickness gauging features of the DFX-544 to calculate the surface distance and depth to a discontinuity from the actual beam path measured. This is accomplished by calibrating the trig mode with the actual refracted angle of the transducer/probe being used. Additionally, the thickness of the test piece must be established in the menu in order to calculate depth and surface distance when using multiple skips in angle beam testing. The measurements being calculated are depicted in Figure 17.

These measurements are displayed below the A-Trace on the DFX-544 as follows:

- Beam path distance $B$ from the central exit point on the transducer/probe to the discontinuity, the sum of $B_1$ and $B_2$ in double skip mode.

- Surface distance $S$ from the central exit point on the transducer/probe to a point directly above the discontinuity on the test piece. By entering the distance from the Front of the Probe to the emission point in the PROBE menu, this distance may be displayed relative to the front of the probe, which is usually more convenient.
Depth distance $D$ from the surface on which the transducer/probe rests to the discontinuity.

It is important to note that discontinuities in welds can be discontinuous and can extend over a distance. The measurements made will, therefore, be close approximations to the discontinuity if the user properly calibrates the DFX-544 and uses care to locate the desired peak amplitude signal to which a measurement is made.

To calibrate and use the trigonometry mode, follow the following instructions:

1. Using a suitable IIW or other calibration block, measure and establish the central sound beam exit point and actual refracted angle for the transducer/probe being used.

2. Establish the zero and velocity (span) for the transducer and material under test using the A-CAL procedure described in Section 6.5.2 on page 86. Use a suitable calibration block that has two drilled holes representing the thin to thick range of thickness expected in the test piece. In the MEAS menu (Section 6.5.2 paragraph 4), set the TRIGGER parameter to PEAK. As in any ultrasonic thickness measuring method, it is important that the calibration be performed using a calibration block of the same material as that being inspected. Alternately, if you know the velocity of sound in the test piece, you may calibrate using the A-CAL method on a different material and then set the velocity parameter.

3. Set the START and WIDTH of Gate1 to encompass the desired testing region.

4. From the Main menu, select MEAS and place the MODE to TRIG.

5. Set the TRIGGER parameter to PEAK.

6. Select the ANGLE parameter and using the INC and DEC buttons, set the refracted angle of the transducer/probe measured in step 1 above.
7. Select the THICK parameter and using the INC and DEC buttons dial in the thickness of the test piece. You may have to readjust this parameter if the test piece had varying thickness and you are using a multiple skip mode of angle beam testing.

8. When measuring a discontinuity, position the transducer/probe so as to obtain the maximum amplitude signal before recording the readings. A typical TRIG mode display is shown in Figure 18 above.
6.4.5 Weld Inspection Using the AWS Menu

The AWS menu (available on Models sold in certain countries where the AWS methods are used such as the United States, Canada and Mexico) provides a means for evaluating discontinuities when inspecting welds in accordance with the American Welding Society’s Structural Welding Code, ANSI/AWS D1.1-94. The user is referred to the AWS standard for full details of the method.

The AWS menu provides a convenient method of automatically calculating the “Indication Rating” (IR) as defined by the standard. The AWS menu can be used in conjunction with the trigonometry mode which will simultaneously indicate beam path, surface distance and depth distance at the bottom of the graticule. The AWS menu will not operate with either the DAC or TCG switched on.

To set up the AWS measurements, perform the following:

1. Calibrate the DFX-544 for weld testing and set up the trigonometry mode by following the steps in Section 6.4.4 on page 72.

2. From the FN menu, select AWS and place the MODE to SET.

3. Highlight REF on the menu and set to the desired reference level, usually 80% of full screen height.

4. Place the probe on the test block and obtain the maximum signal from the reference indication.

5. Place the cursor over the indication by selecting ADJUST CURSOR and using the INC and DEC arrow keys.

6. With the signal maximized, press the ACCEPT key.

The DFX-544 is now calibrated to make Indication Rating measurements in accordance with AWS D1.1-94. To use the AWS mode, do the following:

1. On the AWS menu, highlight MODE and select MEAS.
2. Ensure that the gate and measurement (TRIG) function are operative and properly adjusted.

3. When the AWS menu is selected and a signal is in the gate, the sub-menu boxes will show the resulting AWS measurements as follows:

\[ \text{IR} = \text{IL} - \text{RG} - \text{AF} \]

(Indication Rating = Indication level – Reference Gain – Attenuation Factor)

Where:

- **IL**: Indication Level is the dB setting required to bring an indication to the reference level.

- **RG**: Reference Gain is the dB setting of the calibrated reference indication as a function of the reference standard and probe being employed.

- **AF**: Attenuation Factor is the attenuation factor required by the AWS standard and is: Depth in inches minus 1, multiply by 2 and then rounded to the nearest \( \frac{1}{2} \) dB.

- **IR**: Indication Rating is the difference in dB between the indication and the reference gain with attenuation factor correction.

It is not necessary to bring the indication to the reference level to obtain the correct measurement information as the DFX-544 adjusts for gain offset. However, to ensure the best accuracy of calculation, it is advised to adjust the indication to be above 40% and below 100% of full screen height. In addition, in the AWS mode, gain offset is shown as +/- dB from reference as opposed to absolute gain.
6.4.6 A-LOG, A-Scan Storage

The A-LOG feature provides for storage, recall and printing of A-Scans with all of the instrument settings. Up to 100 A-Scans and their settings can be stored. This feature is useful to record an indication for later review or for printing a hardcopy. In addition, recalling an A-Scan and its settings will allow for easy follow-up inspection of the same indication on the test piece. Simply unfreeze the display after recalling and the DFX-544 is ready to repeat the same inspection. Be sure to use the same transducer that was use for the original recording.

To store an A-Scan:

1. Establish the basic calibration of the DFX-544 using the desired transducer/probe and the proper reference block.

2. From the MEMORY menu, select the A-LOG feature.

3. Select the STORE parameter by pressing the yellow button next to it and use the INC and DEC buttons to select a store location. The STATE parameter shows whether the store location is VALID (used) or EMPTY. Be careful not to store over a valid location unless you desire to erase what is there and replace it with the current A-Scan and settings.

4. Select the MODE parameter by pressing the yellow button next to it and use the DEC button to select STORE.

5. Obtain a desired echo from a discontinuity or reference block. Optionally press the FZ/PK button to freeze the display before storing it. If you regularly use the FZ/PK button to freeze the display before storing it, you can obtain the echo first (Step 5) and then go to the A-LOG menu and select the location and function (Steps 2-4). The signals will be “filled-in” on the display and the resultant width of the envelope or “echo dynamic pattern” will infer the crack length.

6. To use the echo dynamic pattern feature, position the transducer/probe just off one side of the indication. Press the
FZ/PK button twice to activate the Peak mode, which is indicated,

7. Press the OK button to store the waveform and instrument settings. At the CONFIRM prompt, press the OK button again to store the A-Scan or press the INC button to continue without storing the A-Scan.

8. After pressing the OK button a second time, the NOTES window opens automatically to allow the creation of any desired notes for the stored A-Scan and its settings. See the section *Adding NOTES to PANEL and A-LOG sets* on page 60. When finished adding notes, press the yellow button next to the STORE parameter to return A-LOG menu.

To recall an A-Scan:

1. From the MEMORY menu, select the A-LOG feature.

2. Select the STORE parameter by pressing the yellow button next to it and use the INC and DEC buttons to select the desired store location to be recalled. The STATE parameter shows whether the store location is VALID (used) or EMPTY.

3. Select the MODE parameter by pressing the yellow button next to it and use the DEC button to select STORE.

4. Press the OK button to recall the waveform and instrument settings. This may tack a couple of seconds at which time the instrument will return to the main menu and the display will be in Freeze mode. To return to normal testing mode with the recalled settings, press the FZ/PK button twice.

5. Alternately, you may review the notes pages stored with each A-LOG to determine which set you want to recall. Set the MODE to LIST and using the STORE parameter, move through each one to view the Notes page. When the desired A-LOG is found, press the OK button to recall it. To remove the notes review window, set the MODE back to STORE, RECALL or DELETE.
To delete a stored A-Scan, follow the steps above but set the
MODE parameter to DELETE and then press the OK button. At
the CONFIRM prompt, press the OK button again to delete the
A-Scan or press the INC button to continue without deleting the
A-Scan.

To edit notes in an A-LOG, press the yellow button next to the
EDIT NOTES parameter and then follow the instructions in the
section on *Adding NOTES to PANEL and A-LOG sets* on page 60.

**NOTE:** When notes are displayed, the menu cursor buttons are
disabled. Switch off list mode to change to another menu.

6.4.7 **REF, Reference Waveform Comparisons**
This feature allows the user to select a waveform from one stored
in the A-LOG menu, and to display this reference waveform on the
graticule along with the real time waveform. This makes easy
comparisons possible between an expected signal response (the
reference waveform) and that obtained from the test piece.

To recall an A-Scan as a reference waveform:

1. In order for a reference waveform to be recalled, the required
trace must first be stored into an A-LOG store.

2. From the MEMORY menu, select the REF feature.

3. Select the STORE parameter by pressing the yellow button
next to it and use the INC and DEC buttons to select a store
location. The STATE parameter shows whether the store
location is VALID (used) or EMPTY.

4. Select the MODE parameter by pressing the yellow button
next to it and use the DEC or INC button to select RECALL. If
set to LIST, the note associated with the reference waveform
will be displayed.

5. Press the OK button to display the reference waveform on the
graticule. The reference waveform will be a different color as
compared to the real time waveform, depending on which color is chosen.

6. To remove the reference waveform, set the MODE to OFF and press the OK button.

**NOTE:** When the reference is recalled, no setting parameters are changed. Therefore, if the RANGE or DELAY are subsequently changed, the reference signal will not match the real time waveform. This means that the RANGE and DELAY used for storing the reference waveform in A-LOG must match that used for the comparison of real time signals to the reference waveform. The reference waveform cannot be displayed in video colors 0 and 1 (All white and all yellow).

**6.4.8 Contour & Peak Echo Dynamics**

During flaw testing it is sometimes difficult to determine the exact peak of a discontinuity echo due to its geometry, coupling and surface anomalies and part geometry. The DFX-544 incorporates a unique Peak feature that, while activated, stores all of the signal excursions on the display using a fill technique.

In addition to providing an effective method of capturing peak echo information, the Peak mode is useful for crack tip diffraction methods in angle beam weld inspection. In the case of crack tip diffraction, the extent of a crack type discontinuity can be inferred by the positional excursions of the signal as it reflects from both tips of a crack. Thus, as the transducer/probe is moved past the indication, the signals will be “filled-in” on the display and the resultant width of the envelope or “echo dynamic pattern” will infer the crack length.

To use the echo dynamic pattern feature, position the transducer/probe just off one side of the indication. Press the FZ/PK button twice to activate the Peak mode which is indicated by a box-displaying PEAK below the graticule. Move the transducer/probe past the indication to fill-in the envelope pattern. In the case of angle beam testing, it is advisable to rotate the transducer/probe slightly and move it from side to side while
moving forward past the indication. This will assure the capturing of all amplitude and distance information. An example of peak echo mode capture is shown in Figure 19.

To return the display to normal mode, press the FZ/PK button a third time. This will erase the envelope pattern and return the instrument to the instantaneous mode of display. While the display is showing the dynamic echo pattern, it is possible to record the A-Scan as indicated in Section 6.4.6 on page 77.

Figure 19 – Peak Echo Dynamics
6.5 **Thickness Gauging**

6.5.1 **Basic Thickness Gauging**

Accurate and reliable thickness gauging requires three important considerations: a) proper transducer/probe selection, b) an accurate reference block of the same material as that being tested, and c) proper calibration of the instrument. The following are the basic guidelines for accurate thickness gauging but the user is referred to Section 1.3 on Operator Training for advice on seeking in-depth training.

There are three types of transducer/probes used in ultrasonic thickness gauging, all employing the straight or longitudinal beam method. The single element contact transducer/probe is used for general purpose thickness gauging where material thickness is generally expected to be above 2.5mm. The delay line contact transducer/probe is used for measuring thin material down to 0.5mm where the surfaces are clean and parallel. The dual element contact transducer/probe is used for moderately thin materials down to about 1.0mm where the surfaces may be irregular and not necessarily parallel. The dual transducer/probe is most commonly used for corrosion thickness inspection where its ability to obtain echoes from pitting is superior. Nevertheless, dual transducer/probe inspection on corroded materials is nowhere near as accurate as single element and delay line inspection, due to the nature of the material under test. In addition, the dual element transducer/probe usually incorporates a slight included angle on both the transmit and receive side, resulting in a small non-linearity of the measurements. For this reason, dual transducer/probe thickness testing is usually calibrated and performed over a limited thickness range.

Regardless of the type of transducer/probe used, it is important that it be specifically designed for thickness gauging. This means that it must have broadband or highly damped characteristics that provide a sharp leading edge. Otherwise, amplitude variations of the signals can cause half-wavelength errors due to smaller "build-up" echoes as shown in Figure 20 and Figure 21.
The next requirement for thickness gauging is a calibration or reference block. This block should be made of the same material as the components to be inspected. In other words, it should have the same sound velocity and attenuation characteristics. The calibration block should have parallel machined surfaces representing the thickness range to be inspected. Although two thicknesses representing the minimum and maximum values are sufficient for calibration, it is recommended that the calibration block have four sections covering the range anticipated. This will allow for verification of the calibration.

It is possible to calibrate the DFX-544 using a generic test block and only one known sample thickness of the material under inspection. This is a less desirable method because there is no way of verifying the calibration. With this method, the calibration would first be performed on the generic test block, which would have three to four sections covering the expected thickness range. Essentially, calibrating on the generic block would set the transducer/probe zero point. Then the DFX-544 Velocity would be adjusted on the known sample of the test material until the thickness readout matched the known thickness. This established the sound velocity for the test material.
Finally, it is necessary to establish the proper calibration of the DFX-544 in order to assure accurate and reliable thickness testing. The essence of this calibration is to set the pulser and amplifier characteristics to provide sharp leading edges on the echoes. The following are the essential steps for basic thickness gauging:

1. Select the appropriate broadband transducer/probe and calibration block that matches the material under test.
2. In the CAL menu, select the proper Range and Delay so those echoes from the range of thickness can be viewed.
3. From the AMP menu, set the Frequency to the nominal value of the transducer/probe and set the detection mode to RF.
4. In the TX menu set the Mode to Single for delay line and single element transducer/probes and to Double for dual element transducer/probes.
5. Couple the transducer/probe to a mid-range thickness section on the calibration block and obtain an echo.
6. From the TX menu, adjust the TX Width parameter so as to obtain the maximum amplitude from the echo while maintaining a symmetrical shape to the echo.
7. From the TX menu, adjust the Damping parameter to obtain good broadband echo characteristics. The echo should be narrow with a minimum of cycles and a strong first half-cycle, either positive or negative. Ideally, one side of the RF echo should have a first half-cycle which is higher in amplitude than the remaining half-cycles.
8. Repeatedly adjust both the TX Width and the Damping parameters until the echo shape is optimized.
9. From the AMP menu, set the Detect parameter to either -VE or +VE, depending on which half of the RF provides the best half-cycle as determined in step 7 above.
10. Adjust the gain to set the echo at about 80% amplitude and increase the Reject parameter to remove any undesirable noise from the baseline.

11. From the GATE1 menu, set the gate to ON +VE and adjust the Start and Width so that the gate encompasses the thickness range of interest. Place the transducer/probe between the thin and thick area on the calibration block to verify proper coverage. Adjust the Level parameter to about 30% of full screen.

12. From the MEAS menu, set the Mode parameter to DEPTH and the Trigger parameter to FLANK.

13. If desired, set the T-Min parameter to ON so that the thinnest reading obtained will be held in the display. Reset by using the INC or DEC buttons.

14. If desired, set the HUD parameter to ON to display the thickness in a large window at the top right of the graticule.

15. To calibrate the DFX-544 for thickness readings, follow the steps outlined in Section 6.5.2 below. Alternately, you can use an iterative process from the CAL menu of setting the Zero on the thinnest calibration block sample and the Velocity on the thickest sample. Using this technique, you must repeat Zero to Velocity several times until the two values are correct.

When using a delay line transducer/probe, there are two modes of measurement: a) Interface to first return echo, and b) multiple echo mode which usually measures from the first to the second return echoes after the interface echo.

1. Follow steps 1-10 above.

2. From the MEAS menu, set the Mode to E-E for echo to echo measurement. You will notice that a second gate bar appears below Gate1 and that its start point is slightly to the right of Gate1. This is the Blocking gate explained below.

3. For measuring from interface to first echo, position the start of Gate1 before the interface echo. Using the Blank parameter in
the MEAS menu, position the start of the second gate just after the interface echo but before the thinnest expected first echo.

4. For measuring multiple echoes after the interface, position the start of Gate 1 just after the interface echo. Using the Blank parameter in the MEAS menu, position the start of the second gate just after the first echo but before the thinnest expected second echo.

5. The Blank parameter determines the blanking or starting position of the second gate relative to the starting position of Gate 1. This prevents noise and spurious echoes associated with the interface or first echo from terminating the measurement and producing a false reading.

For storage and printing of thickness readings, refer to Section 6.5.4 on page 89 and Section 6.5.6, *T-FN Thickness Log Editing and Printing* on page 92.

6.5.2 A-Cal

A-CAL is an automated calibration feature for thickness gauging applications or when measuring depth to an indication in flaw testing.

In order to achieve proper calibration for measuring time-of-flight in ultrasonic testing, two factors must be known; the velocity of sound in the material under test, and the offset of the transducer/probe caused by wearface and phase shifts.

Conventional thickness calibration technique usually requires setting the zero (offset) and span (velocity) using an iterative technique. This means alternately placing the transducer/probe on a thin sample to set the zero and a thick sample to set the span. This process is repeated several times until both readings are correct. The reason for this is that raising the span will also raise the zero.

The A-CAL feature automates this process so that only two readings are required, one on the thin sample and one on the thick
sample. The DFX-544 then calculates the correct offset and span factors and sets the velocity and zero. Any time the test material is changed (velocity) or the transducer/probe is changed (zero); this procedure must be repeated. Using this calibration function results in faster calibration of the instrument and more accurate measurements.

The A-CAL calibration procedure is as follows:

1. Select a test block of the same material as that being inspected, with reference thickness covering the minimum to maximum thickness expected in the test parts. The difference between the thick sample and the thin sample should be no less than five to one.

2. From the Main menu, select CAL and adjust the RANGE and DELAY so that the thin and thick reference echoes show on the display.

3. From the Main menu, select GATE1 and place the STATE in ON +VE. Adjust the START and WIDTH of the gate to encompass the echoes from the thin and thick samples.

4. From the Main menu, select MEAS and place the MODE to DEPTH.

5. From the FN menu, select the A-CAL menu.

6. Select DIST1 using the adjacent yellow button. Adjust the value using the INC and DEC buttons to the known thickness of the thin sample.

7. Place the transducer/probe on the thin reference sample and obtain an echo. Adjust the gate start if necessary to obtain distance readout of the echo.

8. Press the OK button to log the echo.

9. Select DIST2 using the adjacent yellow button. Adjust the value using the INC and DEC buttons to the known thickness of the thick sample.
10. Place the transducer/probe on the thick reference sample and obtain an echo. Adjust the gate width if necessary to obtain distance readout of the echo.

11. Press the OK button to log the echo.

12. Select ACCEPT CAL using the adjacent yellow button.

13. Press the OK button. The transducer/probe zero and velocity will now be adjusted.

The DIST1 and DIST2 values can be stored when the calibration information in PANEL and A-LOG functions are stored. This overcomes the need to set these values and gate positions every time a calibration is desired. Once established, all that is required is to obtain each echo and press OK, and then press OK on ACCEPT CAL and the instrument is calibrated.

If a delay transducer/probe is used set DIST1 to 0.0 and use the interface echo as the thin reference echo. The instrument will then set the transducer/probe zero to compensate for the delay line.

Once calibrated, it might be desirable to record the velocity and zero values from the CAL menu for future reference. Note that this is a convenient method for determining the velocity of sound in an unknown material. Once the DFX-544 is calibrated on a know material, all that needs to be known is one fixed thickness point and the velocity can be determined.

6.5.3 TCG for Reliable Gauging

As previously mentioned, reliable thickness gauging requires that the shape of the echoes be consistent with sharp leading edges. When measuring the thickness of material with higher than normal attenuation to ultrasonic energy or a wide thickness range, it is difficult to maintain proper characteristics of the echoes. One way to overcome this is to use the Time Corrected Gain feature of the DFX-544. TCG can improve the reliability of thickness gauging by increasing the amplitude of echoes from thicker sections of the test material so as to maintain the correct detection threshold on
the leading edge. The objective is to equalize the amplitude of echoes over the entire thickness range to be expected.

To set up the TCG feature, refer to Section 6.4.3 on page 69.

6.5.4 T-LOG Thickness Storage (Numeric)
The T-LOG menu provides a convenient method to store thickness readings for record keeping and analysis. The maximum number of readings that can be stored is 2,000. When using the default **Numeric** mode selected from the T-FN menu, each thickness reading is stored under a three level code. The top level is the BLOCK number which can be 1 to 14. This is followed by the LOCation number which can be set between 1 and 2,000. Last is the reading number (NO) itself which can also be between 1 and 2,000.

This hierarchy of coding for a thickness reading allows readings to be associated with physical characteristics of the component under inspection. Thus, it is up to the user to devise a scheme of assigning blocks, locations and readings to the inspection, keeping in mind the maximum combination of 2,000.

To store readings, follow these simple steps:

1. Set up the instrument for the thickness measuring mode as described in Section 6.5.1 on page 82.
2. From the MEMORY menu, select the T-LOG menu.
3. Use the corresponding yellow buttons to select BLOCK, LOC, and NO in turn and INC or DEC the value to obtain the desired location number for storing the thickness.

Note: If a value shows in the THICK box, then a reading has already been stored in that location. Continuing will overwrite that value with the new thickness reading.

4. Obtain the desired thickness reading and press the blue OK button to log the reading. Notice that the NO value automatically increments to the next reading number.
5. To review a reading, select the desired BLOCK, LOC and NO to identify the location. The value in the THICK box shows the reading stored for that location. To print or delete readings, use the T-FN menu.

6.5.5 **T-LOG Thickness Storage (Sequential & Download)**

The Sequential mode of thickness storage allows readings, locations and notes to be transferred between a computer and the DFX-544. Typically, the user would create a thickness location sequence on the computer and download it to the DFX-544, which can then be used to guide the operator when collecting thickness readings. The collected readings could then be uploaded to the computer for further analysis and storage, releasing the DFX-544 to collect readings from another component. When a component is re-inspected, the historical readings can be downloaded to the DFX-544, providing the operator with an instant check of thickness variation while collecting new readings. The new readings can then be downloaded back to the computer for analysis, storage and printing.

To use the Sequence/Download mode, follow these steps:

1. Using suitable software or text editor, generate a location sequence on the host computer. Each location is comprised of a location number (1 to 2000) and a text string of 32 characters. The text strings of 32 characters are subsequently displayed on the DFX-544 as two lines of 16 characters each in a window at the top left of the screen, when the DFX-544 is in the Sequence mode. Generally, the first 16 characters are used to identify the location so as to direct the operator to the proper point for a thickness reading. The second 16 characters are for general use and can be used for the historical readings or baseline readings if this is the first inspection of the component. Character position 23 is reserved for and identifies the PANEL store (1 to 20) to RECALL if AUTO-SET mode is ON.
Note: The protocol for the location sequence and methods for transferring the data to the DFX-544 are fully described in the Communications Manual, stock number 147239.

Note: A software program is available from Dakota Ultrasonics to perform the programming of sequences and the uploading and downloading of data to the DFX-544.

2. Turn on the Sequence mode by pressing the MEM button, selecting the T-FN menu using the blue arrow buttons, pressing the yellow select button next to the ID MODE option, and using the INC button to select the SEQUENCE mode. Once selected, the graticule will reduce in size and a window is drawn on the top left of the screen next to the HUD window which is automatically switched on. The location and thickness data will be shown in the window if any data has been downloaded to the DFX-544. Alternately, the Sequence mode can be turned on by a command from the host computer.

3. Set up the instrument for the thickness measuring mode as described in Section 6.5.1 on page 82.

4. From the MEMORY menu, select the T-LOG menu.

5. If Auto Calibration is desired, press the yellow select button next to the AUTO SET option, and using the INC button, select ON. AUTO SET can only be used if the downloaded location data contains a PANEL store value (A to T) at character position 23 in the data text string, corresponding to a PANEL store location (1 to 20).

Note: If a value shows in the THICK box, then a reading has already been stored in that location. Continuing will overwrite that value with the new thickness reading.

6. Obtain the desired thickness reading and press the blue OK button to log the reading. Notice that the LOC value automatically increments to the next reading number. Any historical reading downloaded from the computer will show in the window on the screen for comparison purposes.
7. To attach one of the four available notes with the reading, press the yellow select button next to the NOTES option, and using the INC or DEC buttons, select OBSTRC (obstruction), PITTING, POOR S/C (poor signal/couplant), or NO BWE (no backwall echo).

8. To review a reading, select the desired LOC number to identify the location. The value in the THICK box shows the reading stored for that location. To print or delete readings, use the T-FN menu.

9. Once all of the readings for a component have been taken, they can be uploaded to the computer for further analysis and storage. The location data transferred is the 32 character string associated with the location, the thickness value, the units of measure, and the notes. Locations with a blank note will contain the characters “OK.”

6.5.6 T-FN Thickness Log Editing and Printing

The T-FN menu provides capability for the printing and deletion of thickness reading stored with the T-LOG feature. With the T-FN feature, it is possible to print or delete a single Location reading, all Locations within a Block, or all Blocks.

To print a single Location:

1. Make sure that the printer is properly connected to the serial port, turned on and on-line.

2. Select the T-FN menu from the MEMORY menu.

3. Select the MODE parameter by pressing the yellow button next to it and pressing the INC button to select PRINT mode.

4. Select the desired Block number by pressing the yellow button next to the BLOCK parameter and using the INC or DEC buttons.
5. Select the desired Location number by pressing the yellow button next to the LOC parameter and using the INC and DEC buttons.

6. Press the OK button to print the thickness reading for the selected Location.

To print all Locations in a single Block:

1. Make sure that the printer is properly connected to the serial port, turned on and on-line.

2. Select the T-FN menu from the MEMORY menu.

3. Select the MODE parameter by pressing the yellow button next to it and pressing the INC button to select PRINT mode.

4. Select the desired Block number by pressing the yellow button next to the BLOCK parameter and using the INC or DEC buttons.

5. Set the Location number to ALL by pressing the yellow button next to the LOC parameter and using the DEC button if not already selected.

6. Press the OK button to print the thickness reading for the selected Block.

To print all Blocks and all Locations:

1. Make sure that the printer is properly connected to the serial port, turned on and on-line.

2. Select the T-FN menu from the MEMORY menu.

3. Select the MODE parameter by pressing the yellow button next to it and pressing the INC button to select PRINT mode.
4. Set the Block number to ALL by pressing the yellow button next to the BLOCK parameter and using the DEC button if not already selected. The Location number will be automatically set to ALL.

5. Press the OK button to print the thickness reading for all of the Blocks and Locations.

To delete any or all Locations or Blocks, follow the instructions above for printing except set the MODE function to DELETE instead of PRINT.
7. Power Supply
The DFX-544 is powered by a Lithium-Ion battery pack, which is shown in Figure 22 below. The power box attaches to the rear of the DFX-544 with two thumbscrews and connects to the instrument via two terminal contact points.

7.1 Lithium-Ion Battery Pack
When fully charged, the battery pack should enable the unit to be operated for 8 hours, (Significantly longer with the LCD display) under typical operating conditions. The battery pack can be charged while mounted to the DFX-544 by use of the
connector on the front panel. Alternately, the battery pack can be charged separate from the DFX-544 by using its own connector shown in Figure 22 above thereby allowing continued operation of the DFX-544 with the use of multiple battery packs.

7.2 Battery Charging
The Dakota Ultrasonics CH700 battery charger shown in Figure 23 below is suitable for use with main supply from 100 to 240 volts AC. The LED on the charger illuminates to indicate power on. When the battery level is low the LED will glow red. When the battery level is almost full the LED will glow yellow. When the battery level is full the LED glows green. The output voltage from the charger is 16.4 Volts DC. The output current when charging is a constant 2.0 Amps. The part number for a battery pack is Y-04.

Figure 23 – Battery Charger

WARNING – CHARGER ONLY - The CH700 is a battery charger only. Any attempt to use it to power a DFD Lite, without a battery fitted, WILL damage your CH700.
8. Interface Connections

The various interface connections are provided in a sealed compartment under a spring-loaded door at the rear of the DFX-544. The connections are shown in Figure 24 below and described in the following.

Figure 24 – Interface Connections
8.1 RS232
The RS232 port on the DFX-544 allows for bi-directional communication between the instrument and a personal computer. Various control commands are available within three general categories; Write parameter values, Read parameter values, and Action commands. The Write and Read parameters allow the computer to set a parameter and to read parameters current value. The Action commands provide special functions such as waveform and thickness logging transfer. It is the D-shaped connector at the bottom.

The communication handshake is as follows:

- Baud rate: 9600
- Parity: None
- Data Bits: 8
- Stop Bits: 1
- Handshake: Hardware

The cable connections for a 9-pin RS232 port are as follows:

<table>
<thead>
<tr>
<th>MS340</th>
<th>PIN</th>
<th>PIN</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>1</td>
<td>1</td>
<td>NC</td>
</tr>
<tr>
<td>RD</td>
<td>2</td>
<td>2</td>
<td>RD</td>
</tr>
<tr>
<td>TD</td>
<td>3</td>
<td>3</td>
<td>TD</td>
</tr>
<tr>
<td>DTR</td>
<td>4</td>
<td>4</td>
<td>DTR</td>
</tr>
<tr>
<td>GND</td>
<td>5</td>
<td>5</td>
<td>GND</td>
</tr>
<tr>
<td>DSR</td>
<td>6</td>
<td>6</td>
<td>DSR</td>
</tr>
<tr>
<td>NC</td>
<td>7</td>
<td>7</td>
<td>NC</td>
</tr>
<tr>
<td>CTS</td>
<td>8</td>
<td>8</td>
<td>CTS</td>
</tr>
<tr>
<td>NC</td>
<td>9</td>
<td>9</td>
<td>NC</td>
</tr>
</tbody>
</table>
The cable connections for a 25-pin RS232 port are as follows:

<table>
<thead>
<tr>
<th>MS340</th>
<th>PIN</th>
<th>PIN</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>1</td>
<td>1</td>
<td>NC</td>
</tr>
<tr>
<td>RD</td>
<td>2</td>
<td>3</td>
<td>RD</td>
</tr>
<tr>
<td>TD</td>
<td>3</td>
<td>2</td>
<td>TD</td>
</tr>
<tr>
<td>DTR</td>
<td>4</td>
<td>20</td>
<td>DTR</td>
</tr>
<tr>
<td>GND</td>
<td>5</td>
<td>7</td>
<td>GND</td>
</tr>
<tr>
<td>DSR</td>
<td>6</td>
<td>6</td>
<td>DSR</td>
</tr>
<tr>
<td>NC</td>
<td>7</td>
<td></td>
<td>NC</td>
</tr>
<tr>
<td>CTS</td>
<td>8</td>
<td>5</td>
<td>CTS</td>
</tr>
<tr>
<td>NC</td>
<td>9</td>
<td>25</td>
<td>NC</td>
</tr>
</tbody>
</table>

A 9-pin to 9-pin communications cable is available from Dakota Ultrasonics under part number 152120.

No cable is available for the 25-pin RS232 port.

A separate Communications manual part number 147239 is available that describes all of the protocol in detail.

### 8.2 Composite Video

The composite video output is for displaying the A-Trace on a compatible television monitor. The output is either NTSC (USA/Japan) or PAL (UK/Europe), depending on the selection in the Video menu inside the FN menu. The screen update rate is 50Hz in PAL and 60Hz in NTSC. The screen will be slightly brighter in the NTSC mode.

It is the second connector from the top with one center pin.
8.3 Proportional Output
An analog proportional output 0 to 10 volts dc, for distance and amplitude of the signal in the gate.

It is the upper connector with two center pins
9. Specifications

Test Range: 1mm to 20,000mm (0.05-800in) at steel velocity. Variable in 1,2,5, sequence, or continuously in 1mm (0.05in) increments.

Velocity: 256m/s to 16,000m/s continuously variable.

Probe Zero: 0 to 999.999µs, continuously variable.

Delay: Calibrated delay from 0mm to 10,000mm in 0.05mm steps at steel velocity (0-400in. in 0.002in steps).

Gain: 0 to 110dB. Adjustable in 0.5, 2, 6, 14 and 20dB steps. Direct access to gain control at all times.

Test Modes: Pulse echo and transmit/receive.

Pulser: Variable square-wave pulse

400V Mode – 100ns to 500ns duration rise/fall times <20ns into 50 ohms.

200V Mode – 20ns –500ns duration, rise/fall time <20ns into 50 ohms

Damping: Selectable between 33, 50, 100, & 400 ohms.

P.R.F. Selectable between 35, 63, 150, 250, 500, & 1,000Hz.

Update Rate: 60Hz (NTSC Mode); 50Hz (PAL Mode).
**Rectification:** Full wave, positive or negative halfwave and unrectified rf.

**Frequency Range:** Five (5) narrow bands centered at 1 MHz, 2MHz, 5MHz, 10MHz, and 15MHz. Wide band at 0.3MHz to >20MHz (-6dB).

**System Linearity:** Vertical ±1% Full Screen Height (FSH). Amplifier accuracy ±0.1dB. Horizontal ±0.4% Full Screen Width (FSW).

**Reject:** 80% linear reject. LED warning light when selected.

**Units:** Metric (mm), inches (in) or microseconds. Selected from menu.

**Display:** Color: High brightness Color TFT LCD panel. Eight (8) Color scheme options. Brightness variable up to 350cd/m²

LCD: monochrome Liquid crystal display, with switchable backlight.

A-Scan area 255 x 200 pixels. Total display area 102.7 x 77.0mm, 320 x 234 pixels.

**Gate Monitor:** Two fully independent gates for echo monitoring and thickness measurement. Start and width adjustable over full range of unit, amplitude variable from 0 to 100% FSH. Bar presentation. Positive or negative triggering for each gate with visual and audible alarms.
Measurement Modes:

Mode 1 - Signal monitor.
Mode 2 - Depth and amplitude of first signal in gate.
Mode 3 - Echo-to-echo distance measurement.
Mode 4 – Trigonometric display of beam path, surface distance and depth of indication.
Mode 5 - T-Min mode for holding minimum thickness reading.
Mode 6 - Gate to Gate

Resolution to 0.01mm (0.001in) for distance measurement, or 1% FSH for amplitude measurement. Large display of measurement at top of A-Scan display.
Measurement mode selectable between peak and flank. All measurement functions available in unrectified rf mode.

Gate Expansion:
Expands range to width of Gate 1.

A-Scan Memory:
Maximum of 100 waveforms stored with complete panel settings. Waveforms may be recalled on display, printed or transferred via RS232 serial interface.

Panel Memories:
Twenty (20) stores for retaining calibrations.
Thickness Logging: Storage for 2,000 thickness readings configured into Block/Location/Number. Calibration settings stored with each Block. Maximum number of Blocks is 14. Unlimited Location/Number values, maximum combination of 2,000 readings. Readings may be reviewed, edited and printed as required.

DAC: DAC curves may be entered and digitally drawn on the display. Reference, -6dB, -12dB, -14dB curves may be selected. DAC curve selected acts as gate for alarm outputs and height measurement in DAC +dB. DAC parameters stored with Panel Memory. Curves comply with ASME and European Standards.

TCG Time Corrected Gain curves may be entered and digitally drawn on the display. The dynamic range of the T.C.G. is 40dB. T.C.G. parameters are stored in panel, A-Log and memory.

AWS The AWS mode is used when inspecting welds in accordance with the American Welding Society’s Structural Welding Code, ANSI/AWS D1.1-94 to automatically calculate the Indication Rating as defined by the code.

Auto-Cal: Provides automatic calibration from two echoes.
<table>
<thead>
<tr>
<th><strong>Reference Waveform:</strong></th>
<th>This menu displays a waveform from one of the A-Log stores as a reference or fingerprint in a Color different from the active display highlighting differences from the reference.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Notes:</strong></td>
<td>Alphanumeric-labeling for panel and A-Log allows the user to enter Notes for storage with A-Scans.</td>
</tr>
<tr>
<td><strong>X-Offset:</strong></td>
<td>Allows the surface distance to be calculated from the front of the probe with X-offset being the distance from the index point to the front of the probe.</td>
</tr>
<tr>
<td><strong>Special Functions:</strong></td>
<td>Display freeze for capturing current A-Scan image. Peak memory for echo-dynamic pattern determination in accordance with BS3923. Help key for instant operator guidance on using the DFX-544.</td>
</tr>
<tr>
<td><strong>Help Key:</strong></td>
<td>For instant operator guidance on using the DFX-544</td>
</tr>
<tr>
<td><strong>Waveform Smoothing:</strong></td>
<td>Gives a smooth signal envelope similar to the video filtering in analog equipment.</td>
</tr>
</tbody>
</table>
Outputs: Full bi-directional serial interface to transfer parameters, thickness readings and waveform memories. Composite video, full PAL or NTSC compatibility. Analog proportional output for connection to X-Y plotter or other external equipment. Proportional outputs programmable to distance or amplitude of signal. Unrectified rf. signal 80mV peak to peak. Synchronization output for start of scan. Gate trigger output on relay contact.

Power Lithium-Ion sealed battery pack, Typically 8 hours operation on color display model at medium display brightness, more on LCD. On-screen indication of battery status.

Charger: Universal mains input 85-260 volts AC

Probe Sockets: BNC or LEMO (factory option)

Temperature: Operating: -10 to +55°C (14 to 131°F) Survivable: -20 to +70°C (-4 to 158°F) Storage: -40 to +75°C (-40 to 167°F)

Environment: To IP67

Size: 255 x 145 x 145mm (10.0 x 5.7 x 5.7in)

Weight: 2.5 Kgs (5.5 lbs.) with Li-ION Cells.
10. **Warranty**

**Warranty/Defects after Delivery:** Immediately upon receipt of the goods the buyer is required to check the goods carefully and thoroughly. In order to benefit from the guarantee, any defect in the product should be immediately reported in writing to Dakota Ultrasonics. Dakota Ultrasonics will make good by repair or by the supply of a replacement or by equivalent adjustment of the price at our sole option, any defects which under proper use appear in the goods within the period of twenty-four (24) calendar months after the goods have been delivered and which arise solely from faulty design, material or workmanship, provided that the goods are carefully packed and promptly returned by you, free of charge, to the Dakota Ultrasonics works unless otherwise arranged. Said goods should be covered while in transit to us and must be accompanied by a written statement detailing the precise nature of the fault and the operating conditions under which the fault occurred. The repaired goods will be returned by Dakota Ultrasonics free of charge.

Save as in this Clause herein before expressed Dakota Ultrasonics shall not be under any liability in respect of defects in goods delivered or for any injury damage or loss resulting from such defects and our liability under this Clause shall be in lieu of any warranty or condition implied by law as to the quality, fitness or merchantability for any particular purpose of such goods.
### Index

#### A

<table>
<thead>
<tr>
<th>Topic</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-CAL</td>
<td>39, 54, 69, 82, 83</td>
</tr>
<tr>
<td>Acoustic</td>
<td>9</td>
</tr>
<tr>
<td>Acoustic Impedance</td>
<td>9</td>
</tr>
<tr>
<td>Alarm Outputs</td>
<td>99</td>
</tr>
<tr>
<td>A-LOG</td>
<td>48, 49, 50, 55, 57, 58, 62, 73, 74, 75, 76, 84</td>
</tr>
<tr>
<td>American Society of Nondestructive Testing</td>
<td>2</td>
</tr>
<tr>
<td>American Welding Society</td>
<td>2, 42, 71, 99</td>
</tr>
<tr>
<td>Amplifier</td>
<td>7, 97</td>
</tr>
<tr>
<td>AMPliifier Menu</td>
<td>31</td>
</tr>
<tr>
<td>Amplitude Response</td>
<td>3, 65</td>
</tr>
<tr>
<td>Angle Beam</td>
<td>16, 17</td>
</tr>
<tr>
<td>A-Scan</td>
<td>7, 23, 24, 29, 30, 31, 34, 35, 49, 50, 62, 64, 68, 73, 74, 75, 77, 95, 97, 98, 100</td>
</tr>
<tr>
<td>A-Scan Storage</td>
<td>62, 73</td>
</tr>
<tr>
<td>ASNT</td>
<td>2</td>
</tr>
<tr>
<td>Attenuation</td>
<td>11, 40, 42, 59, 62, 65, 72, 79, 84</td>
</tr>
<tr>
<td>AWS</td>
<td>2, 42, 71, 99</td>
</tr>
<tr>
<td>Axially</td>
<td>11</td>
</tr>
<tr>
<td>Broad Band</td>
<td>7</td>
</tr>
<tr>
<td>Button</td>
<td>6, 20, 21, 22, 23, 24, 25, 26, 28, 29, 30, 35, 38, 39, 40, 41, 43, 47, 48, 51, 56, 57, 58, 63, 64, 66, 67, 69, 70, 73, 74, 75, 76, 77, 81, 83, 84, 85, 86, 87, 88, 89, 90</td>
</tr>
<tr>
<td>Buyer</td>
<td>102</td>
</tr>
</tbody>
</table>

#### C

<table>
<thead>
<tr>
<th>Topic</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL</td>
<td>26, 28, 29, 38, 39, 60, 80, 81, 83, 84</td>
</tr>
<tr>
<td>Calibration</td>
<td>3, 24, 25, 26, 27, 29, 38, 39, 40, 41, 42, 47, 48, 49, 50, 52, 56, 57, 59, 60, 61, 62, 66, 69, 73, 75, 78, 79, 80, 81, 82, 83, 84</td>
</tr>
<tr>
<td>Calibration Block</td>
<td>3, 27, 29, 39, 59, 60, 61, 62, 66, 69, 73, 75, 78, 79, 80, 81</td>
</tr>
<tr>
<td>CALibration Menu</td>
<td>30</td>
</tr>
<tr>
<td>Calibration Setups</td>
<td>56</td>
</tr>
<tr>
<td>Center Frequency</td>
<td>31</td>
</tr>
<tr>
<td>Certification</td>
<td>2</td>
</tr>
<tr>
<td>Charge</td>
<td>92, 102</td>
</tr>
<tr>
<td>Charger</td>
<td>24, 92</td>
</tr>
<tr>
<td>Clearing the memory</td>
<td>26</td>
</tr>
<tr>
<td>CLICK</td>
<td>43, 54</td>
</tr>
<tr>
<td>CLOCK Menu</td>
<td>46</td>
</tr>
<tr>
<td>Communication</td>
<td>94</td>
</tr>
<tr>
<td>Composite Video</td>
<td>44, 95</td>
</tr>
<tr>
<td>Concave</td>
<td>19</td>
</tr>
<tr>
<td>Connector</td>
<td>24, 91, 92</td>
</tr>
<tr>
<td>Contact</td>
<td>8</td>
</tr>
<tr>
<td>CONTOUR</td>
<td>26, 28, 31, 54</td>
</tr>
<tr>
<td>Controls</td>
<td>6, 20, 29, 45</td>
</tr>
<tr>
<td>Convex</td>
<td>19</td>
</tr>
<tr>
<td>Corrosion</td>
<td>14, 78</td>
</tr>
<tr>
<td>Couplant</td>
<td>4, 15, 52, 88</td>
</tr>
<tr>
<td>Coupling</td>
<td>4, 9, 10, 18, 63, 64, 66, 76</td>
</tr>
<tr>
<td>Crack Diffraction</td>
<td>8</td>
</tr>
<tr>
<td>Critical Operating Factors</td>
<td>2</td>
</tr>
</tbody>
</table>

Back Surface · 59, 60
Base Material · 9
Battery · 6, 24, 44, 45, 91, 92
Battery Box · 91
Battery Pack · 24, 91
Baud Rate · 94
Beam Path Distance · 36, 68
Beam Spread · 3, 13
BLANK · 36, 54
BLOCK · 51, 52, 53, 55, 85, 86, 89, 90
BNC · 24, 101
CURSOR · 40, 41, 42, 48, 54, 58, 63, 66, 71
CURVE · 40, 41, 42, 54, 64, 67

D

DAC · 7, 25, 27, 40, 54, 62, 63, 64, 65, 66, 71, 99
DAC Distance Amplitude Correction
Menu · 40
Damping · 32, 54, 61, 80, 96
Data Bits · 94
dB · 21, 40, 42, 64, 72, 99
Delay · 22, 25, 26, 28, 30, 54, 60, 76, 80, 83, 96
DELETE MODE · 47, 49, 53
Density · 9
Depth distance · 36, 69
Depth of Flaw · 8
DETECT · 26, 28, 31, 54
Diffraction · 8, 43
Dimensional Measurement · 10
Directivity · 10
Disclaimer of Liability · 4
Discontinuity · 3, 4, 9, 10, 11, 13, 17, 59, 60, 61, 62, 64, 65, 68, 69, 70, 71, 73, 76
Distance Echo Correction · 7
DRAW MODE · 41, 42
Dual Element · 14
Dual Probe · 8
Dynamic · 23, 62, 67, 73, 76, 77, 99

E

Echo Dynamic · 23, 73, 76
Echo Freeze · 7
Echo to Echo · 7
EDIT NOTES · 48, 57, 75
Electromagnetic Compatibility · 5
English · 7
Envelope · 23, 73, 76, 77

F

Factory default · 25
Far Field · 11
Far Surface · 9, 59
FLANK · 27, 28, 35, 45, 81
Flaw Detection · 3, 8, 26
Flaw Detector · 1, 2, 6, 7
Focal Length · 18, 19
Focus · 11, 14, 18
Freeze · 7, 23, 74
FREQ · 31, 54
Frequency · 2, 9, 10, 11, 12, 13, 31, 32, 59
Front Panel Controls · 20, 29
Front Surface · 4, 10, 15, 59, 61
Function · 23, 27, 30, 39, 55
Function Menu · 39
FW · 31, 61
FZ/PK · 23, 49, 50, 57, 73, 74, 76, 77

G

GAIN · 26, 27, 28, 29, 30, 32, 35, 38, 39, 40, 41, 42, 43, 45, 46, 47, 49, 50, 51, 52, 53, 64
GATE1 · 26, 28, 34, 54, 62, 81, 83
Gates · 7, 25
Geometric Features · 13
Ghosting · 32
Grain · 11

H

Handshake · 94
Hardcopy · 73
Help · 7, 23, 100
HUD · 27, 28, 35, 52, 54, 81, 87
<table>
<thead>
<tr>
<th>I</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IWI · 69</td>
<td></td>
</tr>
<tr>
<td>Immersion · 8, 18, 19</td>
<td></td>
</tr>
<tr>
<td>Immersion Testing · 18</td>
<td></td>
</tr>
<tr>
<td>Impedance · 9</td>
<td></td>
</tr>
<tr>
<td>Inches · 26, 27, 30, 34, 72, 97</td>
<td></td>
</tr>
<tr>
<td>Incident Angle · 16, 17</td>
<td></td>
</tr>
<tr>
<td>Included Angle · 14, 78</td>
<td></td>
</tr>
<tr>
<td>Inclusions · 9</td>
<td></td>
</tr>
<tr>
<td>Interface Connections · 93</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>L</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamb Wave · 17</td>
<td></td>
</tr>
<tr>
<td>Large Grain · 11</td>
<td></td>
</tr>
<tr>
<td>Lemo · 24, 92</td>
<td></td>
</tr>
<tr>
<td>Lens · 18</td>
<td></td>
</tr>
<tr>
<td>LEVEL · 27, 28, 34, 45, 54</td>
<td></td>
</tr>
<tr>
<td>LIST MODE · 47, 49, 50</td>
<td></td>
</tr>
<tr>
<td>LOC · 51, 52, 53, 55, 85, 86, 88, 89</td>
<td></td>
</tr>
<tr>
<td>LOCation · 52, 85</td>
<td></td>
</tr>
<tr>
<td>Longitudinal · 14, 16, 17, 78</td>
<td></td>
</tr>
<tr>
<td>Longitudinal Wave · 14, 16</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxima · 11</td>
<td></td>
</tr>
<tr>
<td>MEAS · 27, 28, 42, 62, 69, 71, 81, 82, 83</td>
<td></td>
</tr>
<tr>
<td>MEASurement Menu · 35</td>
<td></td>
</tr>
<tr>
<td>Memory Menu · 47</td>
<td></td>
</tr>
<tr>
<td>Menu Tree · 54</td>
<td></td>
</tr>
<tr>
<td>Metric · 7, 25, 26, 27, 97</td>
<td></td>
</tr>
<tr>
<td>Microseconds · 7, 43</td>
<td></td>
</tr>
<tr>
<td>Minima · 11</td>
<td></td>
</tr>
<tr>
<td>Mode · 2, 16, 22, 23, 24, 25, 26, 27, 30, 31, 35, 36, 37, 38, 41, 42, 43, 44, 45, 49, 50, 52, 53, 56, 60, 64, 67, 68, 69, 70, 71, 72, 74, 75, 76, 77, 80, 81, 85, 86, 87, 89, 90, 92, 95, 98, 99</td>
<td></td>
</tr>
<tr>
<td>MODE · 27, 28, 32, 35, 36, 37, 40, 41, 42, 45, 46, 47, 49, 50, 53, 54, 55, 56, 57, 63, 64, 66, 67, 69, 71, 73, 74, 75, 76, 83, 87, 89, 90</td>
<td></td>
</tr>
<tr>
<td>Mode Conversion · 2, 16</td>
<td></td>
</tr>
<tr>
<td>Multiple Echo · 81, 82</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Near Field · 3, 11, 12, 18</td>
<td></td>
</tr>
<tr>
<td>NiCd · 24, 91, 101</td>
<td></td>
</tr>
<tr>
<td>Nondestructive · 6, 10</td>
<td></td>
</tr>
<tr>
<td>Nondestructive Inspection · 10</td>
<td></td>
</tr>
<tr>
<td>Notes · 38, 47, 48, 49, 50, 52, 56, 57, 58, 74, 75, 86, 88</td>
<td></td>
</tr>
<tr>
<td>Notes Window · 58</td>
<td></td>
</tr>
<tr>
<td>NTSC · 43, 44, 95, 96, 101</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>O</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>O/P · 45, 46, 53, 55</td>
<td></td>
</tr>
<tr>
<td>Operator Training · 2, 59, 78</td>
<td></td>
</tr>
<tr>
<td>Orientation · 3, 59</td>
<td></td>
</tr>
<tr>
<td>Outputs · 7, 45, 100</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P_O/P Proportional Output Control</td>
<td></td>
</tr>
<tr>
<td>Menu · 45</td>
<td></td>
</tr>
<tr>
<td>PAL · 25, 44, 95, 101</td>
<td></td>
</tr>
<tr>
<td>Panel Calibration · 24, 25, 56, 57</td>
<td></td>
</tr>
<tr>
<td>PANEL Setup Menu · 47</td>
<td></td>
</tr>
<tr>
<td>Parameter · 21, 22, 26, 27, 28, 29, 56, 57, 61, 62, 63, 64, 66, 67, 69, 70, 73, 74, 75, 80, 81, 82, 89, 90, 94</td>
<td></td>
</tr>
<tr>
<td>Parity · 94</td>
<td></td>
</tr>
<tr>
<td>Peak · 7, 23, 74, 76, 77, 100</td>
<td></td>
</tr>
<tr>
<td>Peak Echo Dynamics · 7, 76, 77</td>
<td></td>
</tr>
<tr>
<td>Penetration · 11</td>
<td></td>
</tr>
<tr>
<td>Piezoelectric · 10</td>
<td></td>
</tr>
<tr>
<td>Pipe · 15</td>
<td></td>
</tr>
</tbody>
</table>
Pitting · 14, 78
Planar · 10, 60
POINT · 40, 41, 42, 54, 63, 66
Porosity · 9, 17
Power Supply · 24, 91
PRF · 25, 32, 54
PRINT Menu · 38
Printing · 38, 53, 62, 73, 82, 86, 88, 90
Probe · 3, 4, 8, 9, 10, 11, 12, 13, 14, 15,
16, 17, 18, 19, 22, 24, 26, 27, 30, 31,
32, 36, 39, 40, 56, 59, 60, 62, 63, 64,
66, 68, 69, 70, 71, 72, 73, 76, 78, 79,
80, 81, 82, 83, 84
Probe Calibration · 3
Probe Pressure · 63, 64, 66
Probe Zero · 3, 22, 39, 79, 84, 96
Pulse · 96
Pulse Repetition Frequency · 32
Pulse-Echo · 8

Q

Qualification · 2

R

Radially · 11
Radio Interference · 5
RANGE · 26, 28, 30, 54, 76, 83
Recall · 22, 56
RECALL MODE · 47, 49, 50
Receiver · 24
REF Feature · 42, 51, 52, 71, 75
REF/GAIN · 29
Reference · 21, 72, 75, 99
Reference Block · 3, 59, 62, 63, 64, 65,
66, 73, 78, 79
Reflection · 9
Reflected Sound Beams · 17
Refraction · 16, 17, 18, 19, 68, 69
REJECT · 26, 28, 31, 54
Reliability · 18, 84
Reset · 25, 35
Resolution · 11, 14, 18, 45, 59, 60, 61
RF · 7, 31, 41, 60, 67, 80
RS232 · 7, 38, 53, 94, 98

S

Scatter · 11
Self Check · 7
Sensitivity · 10, 11, 18, 27, 59, 60
Shear · 8, 16, 17
Shear Wave · 8, 16, 17
Single Probe · 8
Size · 101
Skips · 36, 68
Socket · 24
Sound Energy · 9, 11, 14, 16, 18
Sound Field · 11
Sound Velocity · 2, 8, 9, 11, 12, 13, 30,
69, 82, 84
Sound Wave Propagation · 2
Specifications · 2, 96
Spurious Indications · 17
START · 27, 28, 34, 39, 54, 69, 83
STATE · 27, 28, 34, 47, 49, 50, 54, 55,
56, 73, 74, 75, 83
Stop Bits · 94
Storage · 22, 47, 49, 50, 51, 52, 62, 73,
82, 86, 88
Store · 22, 47, 48, 49
STORE · 47, 49, 50, 55, 56, 73, 74, 75
Straight Beam · 14
Surface · 8, 17, 36, 68
Surface Distance · 36, 68, 71, 98
Surface Wave · 8, 17, 59

T

TCG · 25, 41, 42, 54, 62, 65, 66, 67, 71,
84, 85
TCG Time Corrected Gain Menu · 41
Temperature · 3, 101
<table>
<thead>
<tr>
<th>Term</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Variations</td>
<td>4</td>
</tr>
<tr>
<td>Test Blocks</td>
<td>3, 4</td>
</tr>
<tr>
<td>Testing Limitations</td>
<td>2</td>
</tr>
<tr>
<td>T-FN Menu</td>
<td>53</td>
</tr>
<tr>
<td>Thickness Gauge</td>
<td>1, 7</td>
</tr>
<tr>
<td>Threshold</td>
<td>34, 35, 36, 40, 62, 85</td>
</tr>
<tr>
<td>Time Corrected Gain</td>
<td>10, 41, 62, 65, 84, 99</td>
</tr>
<tr>
<td>Time Of Flight</td>
<td>2</td>
</tr>
<tr>
<td>Time-Of-Flight</td>
<td>9, 82</td>
</tr>
<tr>
<td>T-LOG Menu</td>
<td>51, 55, 85, 86, 87, 88</td>
</tr>
<tr>
<td>T-LOG</td>
<td>51</td>
</tr>
<tr>
<td>T-MIN</td>
<td>27, 28, 35, 54</td>
</tr>
<tr>
<td>training</td>
<td>1, 2, 6, 17, 59, 78</td>
</tr>
<tr>
<td>Transmit-Receive</td>
<td>8</td>
</tr>
<tr>
<td>TRIGGER</td>
<td>27, 28, 35, 40, 45, 53, 54, 55, 64, 69</td>
</tr>
<tr>
<td>Trigonometric</td>
<td>7, 98</td>
</tr>
<tr>
<td>Twin</td>
<td>24</td>
</tr>
<tr>
<td>TX</td>
<td>iii, 32, 37, 54, 60, 61, 80</td>
</tr>
<tr>
<td>TX Transmitter Menu</td>
<td>32</td>
</tr>
<tr>
<td>VALID</td>
<td>47, 49, 50, 56, 73, 74, 75</td>
</tr>
<tr>
<td>VEL</td>
<td>26, 28, 30, 54</td>
</tr>
<tr>
<td>Velocity</td>
<td>2, 8, 25, 43, 79, 81, 96</td>
</tr>
<tr>
<td>Velocity Of Sound</td>
<td>2, 9, 11, 12, 13, 30, 69, 82, 84</td>
</tr>
<tr>
<td>VIDEO</td>
<td>43, 44, 54</td>
</tr>
<tr>
<td>Video Detection</td>
<td>31</td>
</tr>
<tr>
<td>VIDEO Menu</td>
<td>44</td>
</tr>
<tr>
<td>Warranty</td>
<td>102</td>
</tr>
<tr>
<td>Water Path</td>
<td>19</td>
</tr>
<tr>
<td>Wave</td>
<td>8</td>
</tr>
<tr>
<td>Wavelength</td>
<td>10, 11, 32, 59</td>
</tr>
<tr>
<td>Wedge</td>
<td>16</td>
</tr>
<tr>
<td>Weld</td>
<td>7, 17, 36, 42, 59, 62, 68, 71, 76</td>
</tr>
<tr>
<td>Weld Inspection</td>
<td>17, 36, 42, 59, 62, 76</td>
</tr>
<tr>
<td>Weld Zone</td>
<td>17</td>
</tr>
<tr>
<td>WIDTH</td>
<td>27, 28, 32, 34, 54, 69, 83</td>
</tr>
<tr>
<td>ZERO</td>
<td>26, 28, 30, 54</td>
</tr>
</tbody>
</table>